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ON THE COVER

DESPITE its large area, Texas has relatively small rivers, except during flood periods when they wreak their share of havoc. The Brazos has been a bad actor but is gradually being tamed by dam builders. The second barrier to be thrown across it in the past decade is Whitney Dam, a combined earth and concrete structure that is estimated to cost $40,000,000. The concrete section, which will set a new state mark in size, will be 167 feet high and contain 522,000 yards of material. Our cover picture shows two large revolving cranes on a steel trestle that deliver concrete to the forms, 4 cubic yards at a time.

IN THIS ISSUE

MONTREAL is in the center of one of the world's most richly endowed areas for the generation of low-cost hydroelectric power. Existing plants have a capacity of 2,233,000 hp., those under construction will add more than another million, and sites that will yield a further 2½ million are in reserve. A little farther afield are even greater sources of energy, some of them already harnessed. These resources are playing a leading role in Canada's gradual transformation from an exporter of raw materials to one of finished or semifinished products. Page 262.

TO SEGREGATE two materials of different weights, all you have to do is place them in a liquid medium having an intermediate specific gravity. Then the heavier material will sink and the lighter one float. The heavy-media process of separating minerals (Page 244) is based on this simple principle. Bringing it to a commercial stage was not so simple, but it has been achieved. The technique is being extensively applied.

IN THE early 1930's, a group of highway engineers in Iowa developed a simple and effective method of pumping a soil-cement-water mixture under sunken sections of concrete road to restore them to even grade. The technique became known as mud-jacking, and subsequent improvements have made it a popular means of dealing with various highway elevation problems. How the New Jersey Highway Department used it to raise the outer edges of curves on a main thoroughfare is described in an article starting on Page 255.

MOBILE compressor plants on barges are the petroleum engineer's solution of the foundation problem presented by swampy Gulf-Coast areas. Two such craft put in service by The Shell Oil Company are described (Page 258) by J. D. Goodrich, assistant chief engineer in the company's Houston, Tex., office.

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Heavy-Media Separation

New Mineral Concentrating Process is Being Applied to Materials Ranging in Value from Gravel to Diamonds

Walter P. Gillingham

IF YOU put a mixture of sand and sawdust into water the sand will sink and the sawdust float. The obvious reason: Sand is heavier than water, and sawdust is lighter. Put two minerals that differ in specific gravity into a liquid having a specific gravity in between the two and the same thing will happen. The heavier mineral will settle and the lighter one float.

Upon this simple principle are based several new mineral-concentrating methods that have appeared in recent years. The latest and most successful of these is the heavy-media separation process which has made it possible to exploit coal and ore deposits previously considered too low grade to be workable; to treat material discarded in the course of earlier, less-efficient mining and milling operations; and to process more economically many minerals formerly concentrated by other methods. In some cases it has even treated profitably minerals that did not respond to any other means of concentration. Although hardly out of the development stage, it has gained wide acceptance and its use is growing.

At present, fifteen minerals—including coal as well as gravel and diamonds—are undergoing heavy-media separation. There are 46 commercial plants in service, and 23 more are under construction. In addition, 54 laboratory-type test units have been licensed. Beneficiation of coal and minerals is proceeding at the rate of sixteen million tons a year, and by the end of 1949 the figure will exceed 40 million tons. The American Cyanamid Company is the sole technical and sales representative for heavy-media separation, negotiating licenses for the use of the process on behalf of the American Zinc, Lead & Smelting Company, holder of the patents.

The separation of minerals based on differences in specific gravity is known as the sink-float method. It has served mineralogical laboratories for a long time, and the "heavy" liquids used are generally inorganic salt solutions such as zinc or calcium chloride, or it may be a halogenated hydrocarbon like tetrabromethane which has a specific gravity of 2.96 as compared to water's 1.0. Others are available with specific gravities up to 4.9. Their application is simple. For instance, to separate magnesite from dolomite having specific gravities of 3.0 and 2.85, respectively, it is necessary only to place the material, suitably crushed, into a liquid with a specific gravity of about 2.90. The

WHERE FIRST APPLIED

This plant was erected in 1936 at the American Zinc, Lead & Smelting Company's Mascot Mill in Tennessee to replace jigs in treating daily 4000 tons of lead-free zinc ore carrying 5 percent of zincblende. Galena was first used as the sink-float medium but has since been replaced by ferrosilicon. The coarse tailings now obtained are 20 percent heavier than the jig tailings formerly produced but carry only 7 percent of the original zinc values as compared with 11 percent from the jigs. Because the heavy-media unit rejects barren gangue of 2-inch size, crushing costs have been greatly reduced, the tonnage of ore handled daily has been increased with no enlargement of the existing concentration plant, and a reject is obtained that is marketable as ballast or concrete aggregate.

TRI-STATE CONCENTRATOR

The Central Mill of the Eagle-Picher Mining & Smelting Company near Cardin, Okla. Built in 1932 to concentrate ores mined in the Tri-State District of Oklahoma, Missouri, and Kansas, it was the first lead-zinc mill to use heavy-media separation, the process having been introduced on a pilot-plant scale in 1938 and commercially in 1939. It is the largest zinc mill in the world and has handled as much as 18,000 tons of ore a day. Galena was employed as the medium in cone-type separatory vessels until 1945, when a change was made to ferrosilicon.

ANNUAL CAPACITY, IN TONS, OF HEAVY-MEDIA PLANTS IN OPERATION OR UNDER CONSTRUCTION ON JUNE 15, 1949

Material Treated	Plants in Operation	Plants Under Construction	Total
Coal—bituminous and anthracite	7,515,800	12,062,500	19,578,300
Iron ore	3,860,400	3,945,000	7,805,400
Zinc and zinc-lead ore	3,269,900	96,000	3,365,900
Tin ore	744,900		744,900
Magnesite	494,300		494,300
Diamond-bearing ground, fluorspar, lead ore, gravel, garnet, barite, spodumene, andalusite	908,200	4,197,200	4,913,400
	16,793,500	20,300,700	36,902,200

magnesite will sink and the dolomite will float.

Commercial adaptation of the sink-float process has for years been the dream of mineral-dressing engineers. However, the heavy liquids used in the laboratory possess qualities that render them unsuitable for industrial application. Many of them are toxic and must be handled in closed vessels. Furthermore, they are expensive. In spite of these drawbacks, many attempts have been made to utilize them for concentrating minerals on a large scale. But all failed because no economical method of application could be found. Mineral-dressing engineers then turned towards the next-best thing—the development of a simulated heavy liquid that would give the desired results. It is a well-known fact that a finely ground material in water gives a mixture with a specific gravity greater than that of the water alone. It has many of the qualities of a true heavy liquid, and will separate minerals so long as the medium is kept in suspension.

The first attempt to put the idea to practical use in the United States was made in 1920 when T. M. Chance introduced a process of cleaning coal by means of sand and water in a tank of inverted conical shape. Rotating paddles, supplemented by jets of water introduced into the bottom of the cone to create strong upward currents, served to keep the sand in suspension. Coal to be cleaned entered the cone at the top, the slate and other refuse sinking to the bottom while the coal remained on the surface and overflowed on to a washing screen. Although serving well for coal, the system was not adapted for ores because of the low density of the sand-water mixture. Furthermore, it did not permit true gravity separation because the currents introduced buoyant forces. Separation was therefore effected not only on the basis of difference in specific gravity but also on the shape and size of the particles.

Many media other than sand were tried during the next few years. Some worked well, others not so well; but all gave results that forecast the eventual success of the method. Among them were finely ground barites and clay, ground pyrites (iron sulphides), and loess—a loamy clay composed mainly of silica and alumina. Several processes based on these materials were developed in Europe and applied satisfactorily to the cleaning of coal, but none was suitable for ores mainly because the specific gravity was too low.

On the basis of this and other evidence of an experimental nature it was decided that the ideal solid should be, among other things, heavy, hard, easily reduced to fine size, and nonobjectionable in the final product. However, once an acceptable medium was discovered, much remained to be done on the process itself. One of the greatest difficulties experienced was that fine particles of coal or ore became admixed with the medium, making it impossible to maintain the desired specific gravity. Besides, no satisfactory means had been worked out whereby the medium carried away by the separated coal or ore could be recovered and cleaned for reuse.

Heavy-media separation got its start in the early "thirties" when C. E. Wuensch introduced the basic principle of a new sink-and-float concentrating method to operators of the Tri-State lead-zinc district. In addition to utilizing a new medium, galena (lead sulphide), his process differed from earlier ones in three respects: the manner in which the proper density is maintained in the separatory vessel, the removal of the separated products from the vessel, and the recovery of the medium. It offered the following advantages: Elimination of fine gangue and slime from the ores prior to treatment to prevent contamination of the medium; control of grain size, settling rate, and viscosity of the medium; easy recovery, cleaning, and reuse of the medium; and a simple flow sheet adaptable to full-scale operation.

Wuensch obtained the first patents granted in the United States on a sink-float method of mineral concentration based on the principle of stable or semi-stable media of controllable gravity. It is from these patents that the heavy-media separation processes have evolved. The initial commercial application with galena as the medium was made in 1936 by the American Zinc, Lead & Smelting Company at Mascot, Tenn. The installation consisted of a 10-foot-diameter separatory cone capable of handling 4000 tons of zinc ore daily. It marked the first successful use of a simulated heavy liquid for concentrating ores. Results were good. Recovery of zinc as compared with jigs was increased 4 percent, operating costs were reduced, and the flow sheet was greatly simplified.

In 1939 the Mascot plant was followed by another and much larger one at the Central Mill of the Eagle-Picher Mining & Smelting Company near Cardin, Okla. Originally designed to treat low-grade lead-zinc ores at the rate of 10,000 tons a day in a separatory cone 19 feet in diameter, the unit was later

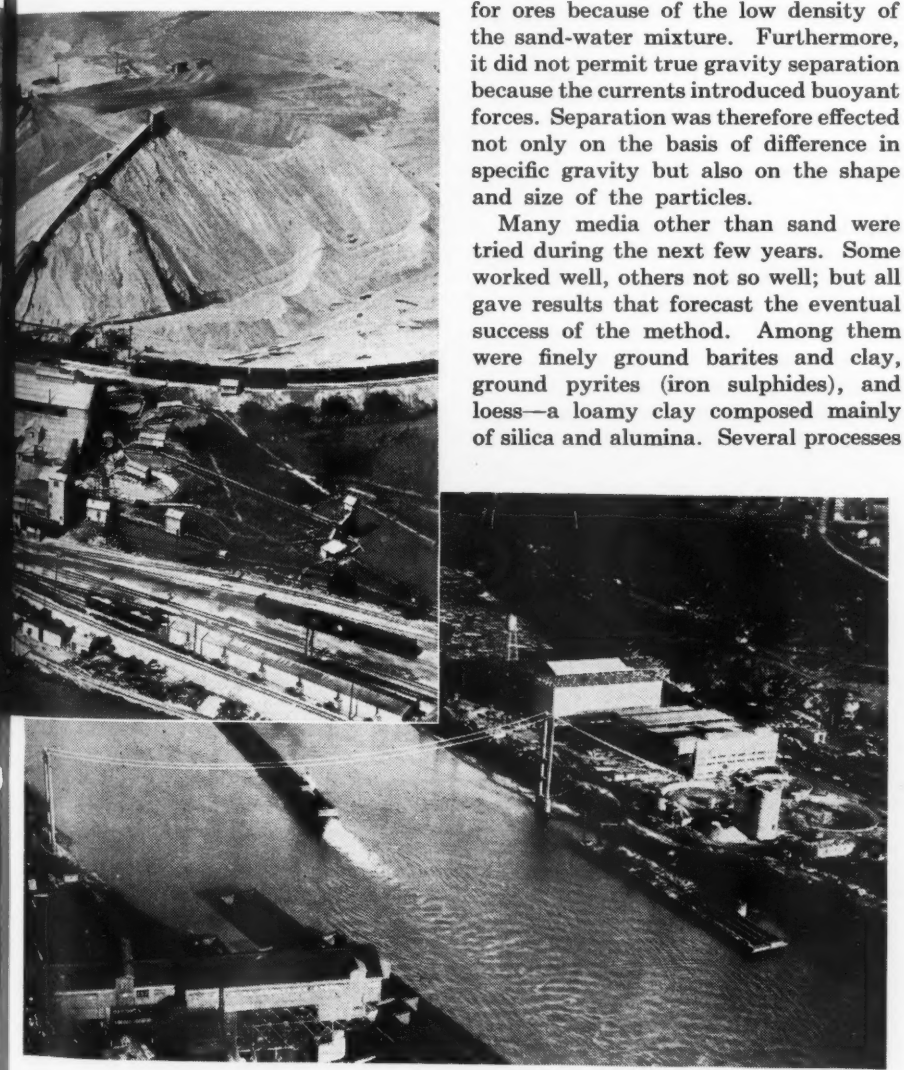


PHOTO F. H. McGRAW & COMPANY

LARGEST HEAVY-MEDIA PLANT

The largest heavy-media plant so far erected as it appeared when nearing completion at the Vesta coal mines of Jones & Laughlin Steel Corporation near Brownsville, Pa. Treating 1500 tons of bituminous coal an hour in drum-type separators, it will make possible completely mechanized, full-seam mining in the Vesta Nos. 4 and 5 collieries. The coal contains considerable shale and other refuse as a result of the mechanical mining method practiced. It will be transported across the Monongahela River from the mines to the plant on a 60-inch-wide conveyor belt supported by a 900-foot-long suspension bridge having a main span 720 feet long. The belt will be enclosed and the interior heated during cold weather to prevent the wet coal from freezing.

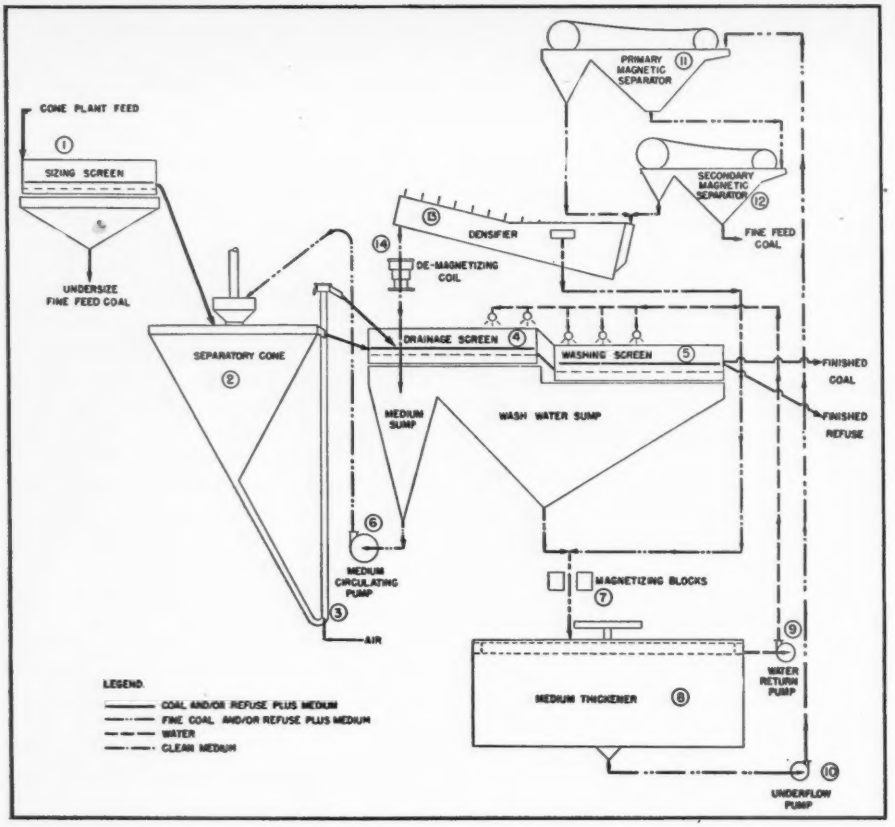


FIGURE 1– HEAVY-MEDIA FLOW SHEET

Outline of typical process using a ferrous medium for treating material coarser than 10 mesh. The diagram is explained in the text.

enlarged to handle 12,000 tons daily. In this case, too, the substitution of heavy-media separation for jigs resulted in improved recovery and lower cost.

Following the successful application of the process on lead and zinc ores, Butler Brothers decided to see what it would do with Minnesota iron ores, and in 1939 built a commercial heavy-media separator, the first on the range, at their Harrison plant near Cooley. In 1937 the company had erected a test unit at its Merritt plant on the Cuyuna Range for the treatment of low-grade iron ores. At the start, galena was used as the medium, but difficulties were encountered not only in maintaining a specific gravity high enough for the iron ore but also in recovering the galena for reuse.

Experiments were then made with an iron-bearing medium that could be reclaimed by magnetic means. Iron filings were tried but turned out to be unsatisfactory because they rusted quickly. Ferrosilicon, a furnace product consisting of iron and silica, was next tested and found to be satisfactory. Butler Brothers thereupon converted their installation to operate with the latter medium. Another ferrous material, magnetite (iron oxide), proved to be suitable at about the same time. Among other advantages, both offer a wider range of density—1.25 to 3.75—than is obtainable with nonferrous media; ease of recovery and cleaning by magnetic means; resistance to abrasion and rust; and low cost. All plants now licensed under the heavy-media-separation patents work with ferrous media.

Essential steps in the process are preparation of the feed, separation of the sink-and-float particles, and recovery of the medium. The procedure involved can best be understood by referring to Figure 1, which is the flow sheet for a cone-type separatory vessel used to beneficiate coal. With minor modifications, it is suitable for other materials. Most of the finer coal is removed from the feed before it reaches the primary sizing screen (1) because particles in the range below 10 mesh generally do not lend themselves to the sink-float method. The material remaining on the screen goes to the separatory vessel (2)

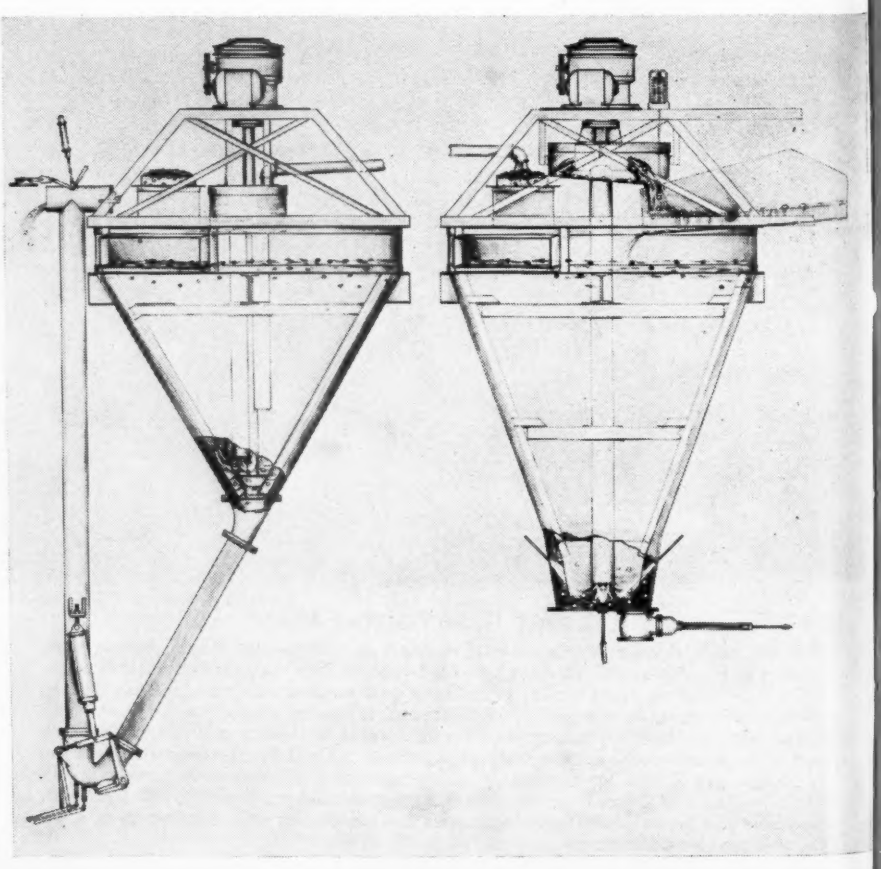


FIGURE 2– TYPES OF AIR LIFTS

The air lift is an integral part of the cone-type separatory vessel. It may be of the external type, shown at the left, or of the internal type pictured alongside. In either case its function is to extract the particles that sink to the bottom of the cone and to elevate them to screens where most of the medium clinging to them can be drained off and returned directly to the separator. Compressed air also operates air cylinders on the external lift. One at the top can be actuated to close the lift and reverse the direction of the air flow so as to clear the pipe when it is obstructed. A bottom cylinder works a valve that provides quick access to the lift in case of a serious stoppage or breakdown. Both separators shown are equipped with motor-driven vanes that revolve at about 5 rpm. to keep the sink particles moving down the sides of the cone to the entrance of the air lift.

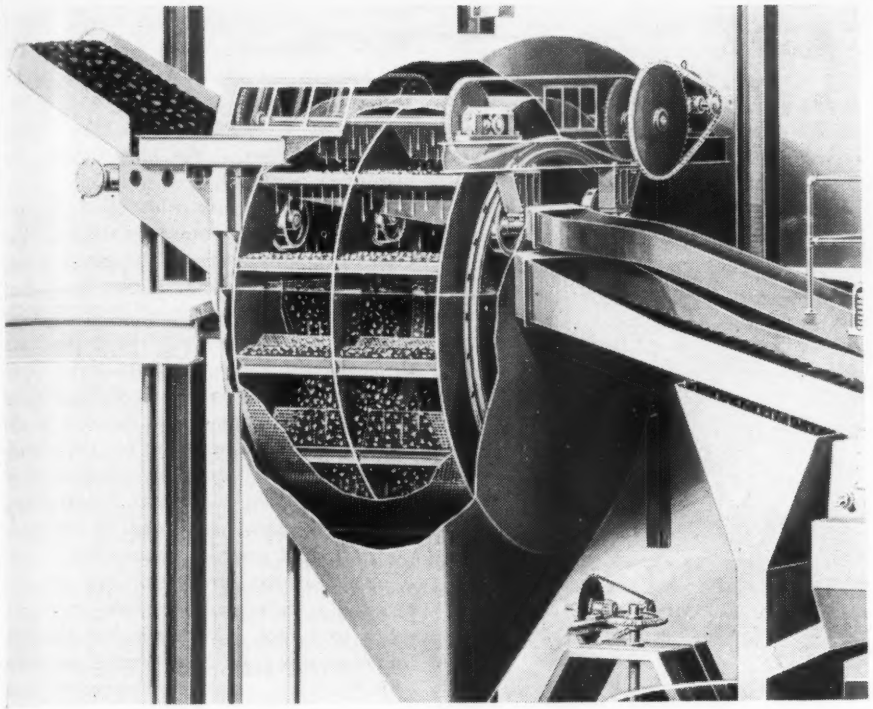


FIGURE 3– DRUM-TYPE SEPARATOR

The Link-Belt Company designed this separator for treating large quantities of coal of sizes that are too big to be handled economically by cone-type vessels. Coal to be cleaned is fed into one end of a 12-foot-diameter revolving drum that is half submerged in the medium. The clean coal floats through the drum and out over a weir, while the heavier high-ash refuse sinks to the bottom and is elevated by numerous shelf-like lifters inside the drum. When the lifters near the top of the vessel, the refuse drops into a chute that directs it to a drainage screen. The drum turns at a speed of approximately 1 rpm. With this type there is no limit to the size of coal that can be cleaned.

which is filled with water and finely ground magnetite, the amount of the latter being closely regulated so as to keep the specific gravity of the medium at the desired point. Upon entering the mixture, the coal floats and continually flows from the vessel over a weir and on to a drainage screen (4), which is divided longitudinally to keep the sink and float products separate.

The refuse—slate, boney coal, and sulphur balls—sinks and is removed from the cone by means of a continuously operating air lift (3), a J-shaped pipe connected to the bottom of the cone. Jets of compressed air introduced into the vertical section of the pipe raise the contained sink particles and medium and discharge them on to their side of the drainage screen. More than 90 percent of the medium adhering to the sink and float products normally drains off at this point and is returned directly to the cone by a centrifugal pump (6). The separated materials then go to a washing screen (5), also divided longitudinally, where substantially complete removal of the remaining medium is effected by water sprays. Cleaned coal is discharged from one side of the screen and refuse from the other.

The medium recovered by use of the water sprays is too dilute and too contaminated with fine impurities to be sent right back to the separatory vessel, so it is diverted to a medium-reclamation thickener (8). Just before it enters the latter it passes between a set of magnetizing blocks (7) that charge the magnetite particles, causing mutual attraction and flocculation. Faster settling is thus obtained, and there is the added advantage of less thickener area and depth than would otherwise be needed. The clear water that overflows from the thickener goes to a pump to be recirculated as spray water.

In addition to dewatering the medium, the thickener provides storage for it during periods of shutdown. It is equipped with rotating rakes that are moved up and down by a power-operated device. When the plant is idle, the rakes are raised, but when work is resumed they are lowered into the thickener, agitating or rendering the settled solids sufficiently mobile so that a centrifugal pump (10) can deliver them continually to a cleaning circuit. When it is necessary to increase or decrease the specific gravity of the medium in the separatory vessel to meet changing characteristics of the feed, larger or smaller amounts of magnetite can easily be introduced by lowering or raising the rakes the required distance in the thickener.

From the thickener the medium goes to the cleaning circuit, which is composed of a primary (11) and a secondary (12) magnetic separator operated in series. These exert a powerful force to separate the magnetite from the nonmagnetic particles of coal or ore and refuse. They are of the belt type and have a magnet assembly mounted just above the lower belt section. The rejected material falls into one hopper and the magnetite, drawn to the belt by the magnetic field, is carried over a second

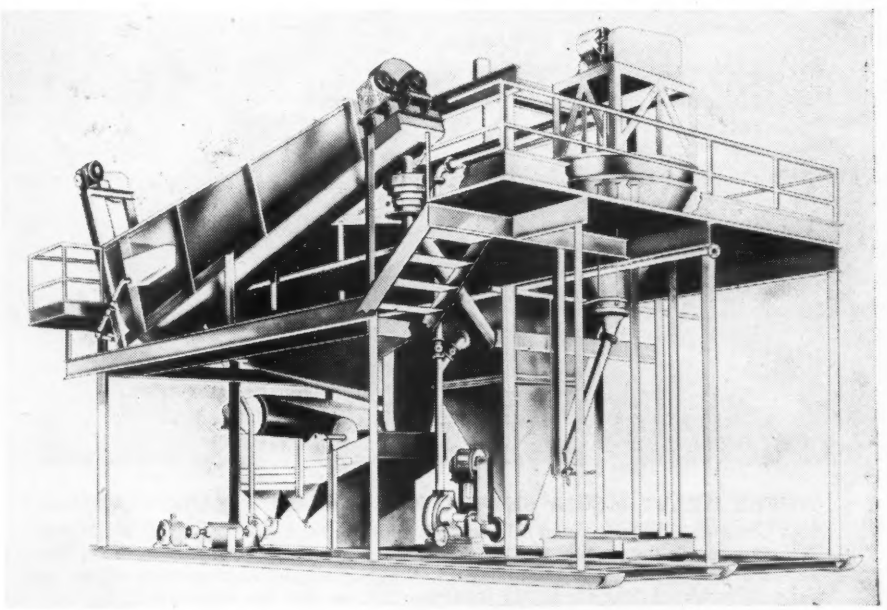


FIGURE 4– THE MOBIL-MILL

A small-capacity heavy-media sink-float unit built by the Western Machinery Company for operations involving limited tonnages. It can be moved easily from place to place. Ferrous media are used in a cone-type separatory vessel, and the flow sheet is essentially the same as that shown in Figure 1. Originally made in sizes ranging in capacity from 10 to 25 tons an hour, it is now available in units that can treat up to 150 tons hourly.

hopper, where it is released. Reject from the primary separator is fed by gravity to the secondary separator, which recovers any remaining magnetite. Tailings from the secondary separator are wasted or, if considered of value because of their fine-coal content, pass to some other form of cleaner.

The magnetite recovered is too diluted with water to go directly to the separatory cone, so it flows to a densifier (13). Essentially a screw-type classifier, the machine is end fed and overflows at the sides—just the reverse of the conventional classifier. It acts not only as a dewaterer but also as a secondary storage reservoir for the clean medium and, in addition, regulates the quantity returned to the separatory vessel. Control of the specific gravity in the latter is effected by raising or lowering the screw to decrease or increase the amount of medium removed from the bottom of the densifier.

At the discharge end of the screw the dewatered magnetite drops into a drainage hopper, whence a pump delivers it to the separatory cone. But before it reaches the hopper, it passes through an alternating-current demagnetizing coil (14) to rid the particles of the charges induced in them by the magnetizing blocks and later strengthened by the action of the magnetic separators. This is an essential step in the heavy-media-separation flow sheet because it gives the medium in the cone the fluidity without which satisfactory operation could not be maintained.

Most heavy-media plants make use of the inverted-cone separatory vessel, the size of the cones ranging from 5 to 20 feet, top diameter. All have air lifts to transfer the sink particles to the drainage screens. They may be of internal or external design, as pictured in Figure 2. Air consumption varies with size, as follows:

Cone Diameter	Air Requirement*	Approximate Cone Feed, Hourly
5 feet	64 cfm.	25 tons
7 "	115 "	60 "
10 "	161 "	125 "

*100 psi. pressure at compressor; 40 psi. at airlift

In addition to the air lift, certain kinds of separatory vessels have pneumatic cylinders which actuate clack valves, as the cone with the external lift in Figure 2 shows. Sometimes a lift becomes plugged with tramp iron or other material and has to be cleared. This can be done with tools, but a quick, effective way is to reverse the air flow in the pipe by means of a cylinder and valve at the top of the lift. A similar arrangement at the bottom provides access to the pipe in case the stoppage persists.

Separatory vessels other than the cone type also are in commercial use. For coal or ore larger than the size the latter can handle economically, Link-Belt Company has developed a drum type (Figure 3). Something like it has been designed by Western Machinery Company, and the Colorado Iron Works has built a spiral-type vessel similar in appearance and operation to the Akins classifier that is standard equipment in most mills. The Nelson L. Davis Company has laid out coal-preparation plants utilizing drum separators.

Heavy-media processes are not restricted to mining operations involving large tonnages. For treating tailings, mine dumps, ore from small deposits, or for preconcentrating material at mills of moderate size, Western Machinery Company has a semiportable unit that incorporates a cone-type vessel ranging in capacity from 10 to 150 tons an hour. It is known as the Mobil-Mill and is pictured in Figure 4. Of prefabricated construction, it is shipped in sections complete with supporting steel, piping and wiring, and can be easily assembled on the job. Eighteen are now in service and eleven more are being built.

At the present time, heavy-media plants are or soon will be in operation in eighteen states, in Alaska, and in four foreign countries. The minerals being concentrated aside from coal, gravel, and diamonds, are: zinc, lead-zinc and lead ores, iron ore, tin ore, magnesite, fluorspar, garnet, barite, spodumene, and andalusite. Laboratory tests indicate that the process is applicable to a wide variety of others such as bornite, chalcopyrite, malachite, topaz, sylvanite, kyanite, gypsum, chromite, manganese ores, tungsten ores, and certain gold ores.

The use of heavy-media in coal preparation has increased at a remarkable rate. In January, 1948, there was one plant in service cleaning bituminous coal. Now there are fourteen, and nine are under construction. Recently, the Vesta Mine of the Jones & Laughlin Steel Corporation at Brownsville, Pa., began processing bituminous coal in a size range of 5 to ¼ inches at the rate of 1500 tons an hour. Fourteen Nelson L. Davis Company drum-type separatory vessels will beneficiate the coal at two gravities to produce both metallurgical and steam fuel. This will be the largest installation of its kind in the world. Last December, the Rhoads Contracting Company of Mahanoy City, Pa., started cleaning anthracite with a Link-Belt drum-type vessel and is now treating hourly 300

WHERE HEAVY-MEDIA SEPARATION REPLACED HAND SORTING

Near Chewelah, Wash., about 60 miles north of Spokane, the Northwest Magnesite Company mines the largest and most important reserves of magnesite ore in the United States. A material little known to the general public, magnesite is used to make refractory bricks for lining furnaces—bricks that are essential in the production of steel, copper, nickel, and other metals. The ore occurs as massive beds in sedimentary rocks containing dolomite, shale, quartzite, and igneous intrusions and is mined in open pits. From 1917, when operations began, until 1941 the ore was separated from impurities by hand sorting. The labor shortage brought on by preparations for World War II necessitated the use of some method of mechanical separation. Construction was therefore begun in June, 1941, on a heavy-media plant with a daily capacity of 3000 tons of crushed ore. It was put in service in October, 1943, and released a considerable number of vitally needed workers to nearby industries and to the armed forces.

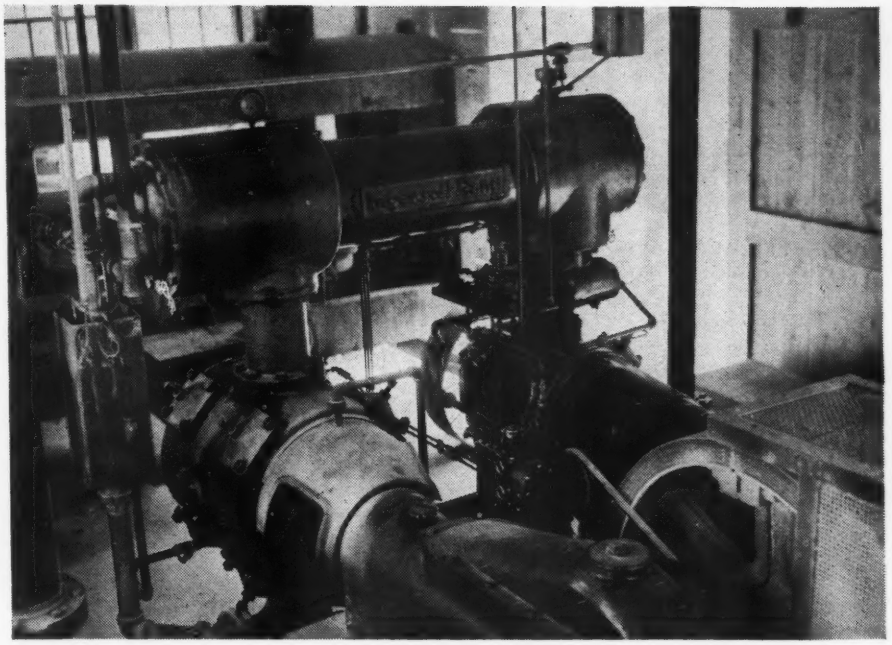
tons of coal 4⅜ to 3/16 inch in size.

Second to coal in number of heavy-media installations and tonnage handled is iron ore. At present there are eight plants on the Iron Range in Minnesota and six others are being built. Four are to be located in other fields. An interesting unit is that at the Grant plant of the Interstate Iron Company at Buhl, Minn. Finding that it was impossible to process iron ore economically in its washery, the company placed a Mobil-Mill in operation in June, 1949, for the beneficiation of 150 tons of iron ore per hour.

Some nine months earlier, the Royal Canadian Air Force had put a unit of this type to an unusual service in constructing an airfield at Rivers, Manit., with a runway for planes weighing up to 180,000 pounds. A total of 120,000 cubic yards of concrete was required for the job. Unfortunately, the gravel locally available contained shale, making it unsuitable as an aggregate. For a time material was transported from other sources at considerable cost, but this was obviated by bringing in a Mobil-Mill with a 7-foot-diameter cone provided with a 6-inch-diameter external air lift. The specific gravity of the shale was 2.0; that of the gravel, 2.6; and that of the separating medium was maintained at 2.43. The equipment handled about 50 tons of gravel an hour, and the concrete made with the aggregate it produced is said to have shown an increase in compressive strength over that hauled from distant borrow pits.

Since the time of Cecil Rhodes, the winning of diamonds from the earth has been accomplished by jigs and pans. In July, 1947, the Premier (Transvaal) Diamond Mining Company, Ltd., of South Africa, broke with tradition by installing a small heavy-media plant to treat diamond-bearing ground at the rate of 80 tons an hour. Based on the results obtained, a larger unit is being built and is to be placed in service late this year. Designed to operate at a specific gravity of 2.95, the cones will separate the feed into 20 percent sink, which will contain the diamonds, and 80 percent float or waste material.

A good example of the narrow limits within which minerals can be classified by means of heavy media is the mill of the Northwest Magnesite Company at Chewelah, Wash., which is separating magnesite from dolomite, quartz, and other impurities. Even though the difference in specific gravity between the magnesite and some of the undesirable gangue is only 0.02, the specific gravity of the medium, maintained at plus or minus 0.01, makes classification possible. The ore is processed in a 20-foot cone at the rate of 145 tons an hour. An external air lift is used to raise the magnesite particles that sink to the bottom of the vessel and is supplied with air at a pressure of 100 psi. by an Ingersoll-Rand 2-stage compressor. By varying the volume of air delivered to the lift, the plant operator can control the amount of medium discharged and, at the same time, its downward progress in the cone to gain an operational advantage.



SOURCE OF PLANT AIR SUPPLY

A belt-driven Type XRB compressor that furnishes compressed air in the plant pictured on the preceding page. When the mill is operating, approximately 130 cfm. is used to lift material from the bottom of the separatory cone to vibrating screens on the next floor level above. During periods of brief shutdown, air is fed into the cone through a pipe running down its center to keep the material agitated so as to prevent settling and possible plugging of the bottom opening and the air lift. The compressor also supplies air to operate overhead hoists, impact wrenches, and other tools used for maintenance and repair work.

In addition to eliminating hand sorting and, incidentally much labor, the Northwest Magnesite Company's installation is actually increasing its ore reserves. In the past, any rock less than 3 inches was considered undersize because it could not be effectively sorted by hand. Large quantities of this ore-bearing material, which has for years been hauled to waste dumps, is to be treated some time in the future.

It is apparent from the foregoing that heavy-media processes not only possess a number of advantages over conventional concentrating methods but are also suitable for handling many kinds of ores. Furthermore, installation, operating, and maintenance costs are generally low, and the milling machinery used, excepting the separatory vessel and the densifier, is of standard type. They effect close separation at any predetermined specific gravity within the range of a specific medium and are flexible in that the specific gravity can be changed quickly and easily to meet changing characteristics of the feed. Plants are largely automatic and can be started or shut down without loss of ores or operating efficiency. Capacities are high, because separation of sink from float takes place in a few seconds and both products are removed continually. A unit having a 7-foot-diameter cone can handle in excess of 1000 tons of ore in 24 hours.

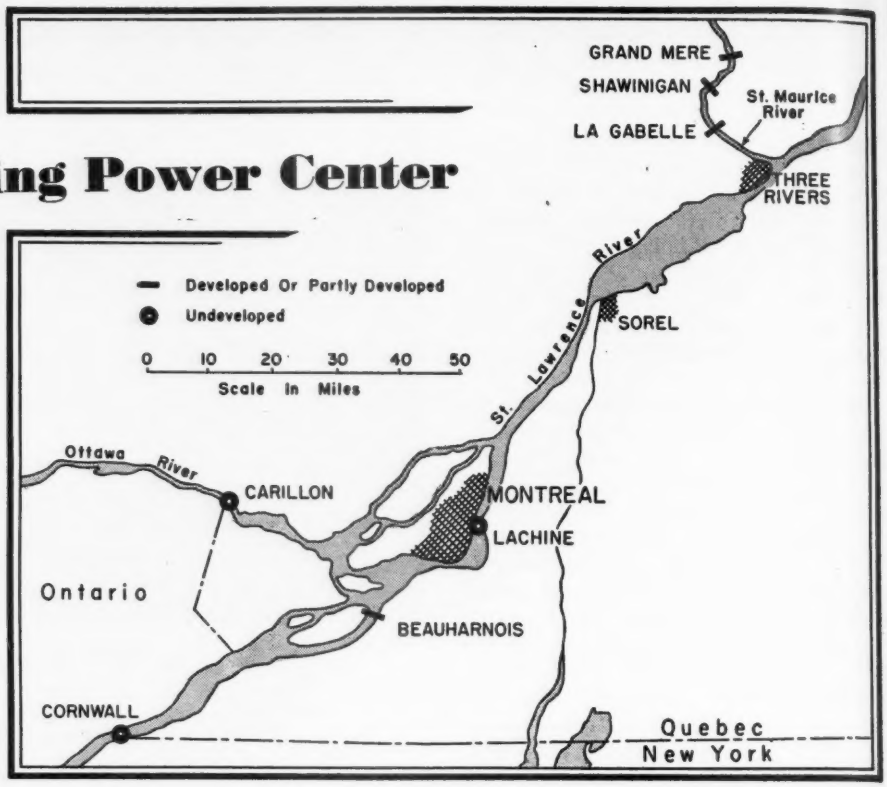
Applications of the processes are many. Besides yielding marketable concentrates, they may be used to reduce over-all milling costs at existing plants by rejecting at a coarse stage much mill feed that is too low in grade for profitable treatment. Coarse tailings obtained by less-efficient concentrating methods may be treated to produce a concentrate from which further recoveries can be made. Cheaper, nonselective mining can be practiced, for it has already been demonstrated that ore diluted with wall rock and low-grade material can be handled profitably. Another worth-while feature of heavy-media separation is that a large-capacity plant fits into a small space and can be installed underground, thus effecting savings in hoisting costs as well as providing backfill material for mined-out stopes.

As a new process, heavy-media separation is fully living up to the claims made for it—in fact it has exceeded them. By making it possible to treat much low-grade material that was formerly not classified as ore, it has effectually increased the ore reserves of the United States at a time when those of some minerals are running dangerously low, thus benefiting not only the mineral industry but also the nation.

Montreal a Leading Power Center

Huge Potential Output of Electricity Assures Bright Industrial Future

W. M. Goodwin



POWER SITES CLOSE TO MONTREAL

Shown here are power sites within 80 miles of Montreal that have a combined potential generating capacity of 5,800,000 hp. Existing plants furnish energy for manufacturing paper at Three Rivers; aluminum, chemicals, and carborundum at Shawinigan Falls; ferrosilicon at Beauharnois; and for refining copper at Montreal. Now under construction at Sorel is a plant that will produce titanium and iron from ore recently developed by Kennecott Copper Corporation at Allard Lake, 600 miles northeast of Montreal.

THE MONTREAL area of Quebec, Canada, is one of the world's most highly favored localities in the matter of low-cost power. Tributary to the city there are a few large sites that warrant an installed capacity of 5,800,000 hp. Of this total, 2,233,000 hp. is developed, 1,020,000 hp. is under construction, and 2,550,000 hp. of potential energy is in reserve. Numerous smaller sources add substantially to these figures.

Round about this central area are other sites as well served by nature. Combined, they account for more than 6,500,000 hp., as follows: Just west of Cornwall in Ontario are the International Rapids in the St. Lawrence where it is proposed to install 2,200,000 hp. Ontario's half of this energy would be used to augment the supply in the industrialized southern part of the province. On the Ottawa River at Ottawa and upstream for 200 miles there are seven locations offering in excess of 1,500,000 hp. Of this, about one-quarter is harnessed and a large percentage of the remainder is under development also for transmission to southern Ontario markets. Tributaries of the Ottawa contribute a further respectable block of more than 900,000 installed horsepower. Northeast of Montreal, on the Saguenay, 2,000,000 hp. is being consumed mainly in the large aluminum plant at Arvida.

The large power resources close to Montreal confer on that area an advantage that would be difficult to match elsewhere. They are, in fact, the main support of the region, which is already highly industrialized with less than 40 percent of its hydroelectric energy in use. By taking a quick look first at the sites and then at the principal primary industries the power supports, it may be possible to envisage the future when another big block of energy is available.

For the present purpose we shall consider the sites on three rivers: those on the St. Lawrence, the Ottawa, and the St. Maurice. The accompanying table and map will help to clarify the discussion. The St. Maurice, which joins the St. Lawrence at Three Rivers 80 miles below Montreal, is unusually well favored in respect to power. Within a total fall of 1125 feet it is possible to use 1011 feet at ten points. Three storage dams have been erected and have trebled the original minimum flow. In time it may be worth-while to create additional reservoirs. Five of the sites are developed and generate 1,265,000 hp., and a sixth is expected to yield an additional 320,000 hp. in 1951.

The Shawinigan Water & Power Company controls the St. Maurice projects and has been a pioneer in supplying Quebec with an abundance of low-cost power. It has also done much to promote its use in the making of primary products for further industrial application, a phase of the subject that will be dealt with later.

The Beauharnois site is one of the world's finest for the economical development of a large block of energy in a single power plant. Between Lake St. Francis and Lake St. Louis, expansions of the St. Lawrence and 14 miles apart, the river drops 83 feet in a series of cascades. Many travelers have enjoyed the thrill of "shooting the rapids" in a small steamship, which returns through the Soulanges canal alongside.

Bordering Lake St. Louis there is a ridge of hard sandstone rising to the level of Lake St. Francis. Behind this,

HORSEPOWER OF LARGE WATERPOWER SITES TRIBUTARY TO MONTREAL

	Ultimate	Developed	Under Construction	Head
St. Maurice	2,200,000	1,265,000	320,000	1011 feet
Beauharnois*	2,000,000	968,000	700,000	83 "
Lachine	1,200,000	——	——	45 "
Carillon	400,000	——	——	60 "
	5,800,000	2,233,000	1,020,000	

*Includes developments alongside the rapids and using a part of the full head

for the full 14 miles, there is nothing but marine clay, except for about a mile of boulder clay. A canal 3000 feet wide has been dug through the marine clay by a giant suction dredge at phenomenally low cost and through the other formation by means of an equally out-size dragline scraper. The only rock work on the job was in the rib of sandstone to provide for a head block and, at the foot of the ridge, for the tailrace. The excavated material was used to make aggregate for concrete for the powerhouse, and the surplus was turned into ferrosilicon in an adjoining plant.

The project was initiated by a private company, but the government of Quebec Province subsequently expropriated the property. It is now operated by the Quebec Hydro Electric Commission, a public body similar to the well-known Hydro of Ontario. The Quebec Commission has recently adopted the policy of producing a substantial surplus of power at Beauharnois as a means of attracting important industries. This accounts for the 700,000 hp. now under construction. It is interesting to note that provision has been made in the case of Beauharnois for the St. Lawrence Deep Waterway. Throughout a part of the canal's width is being dredged a channel of adequate depth, and a suitable site for locks has been reserved alongside the powerhouse.

CANADIAN PACIFIC AIR LINES, LTD.

TYPICAL CANADIAN POWER PLANT

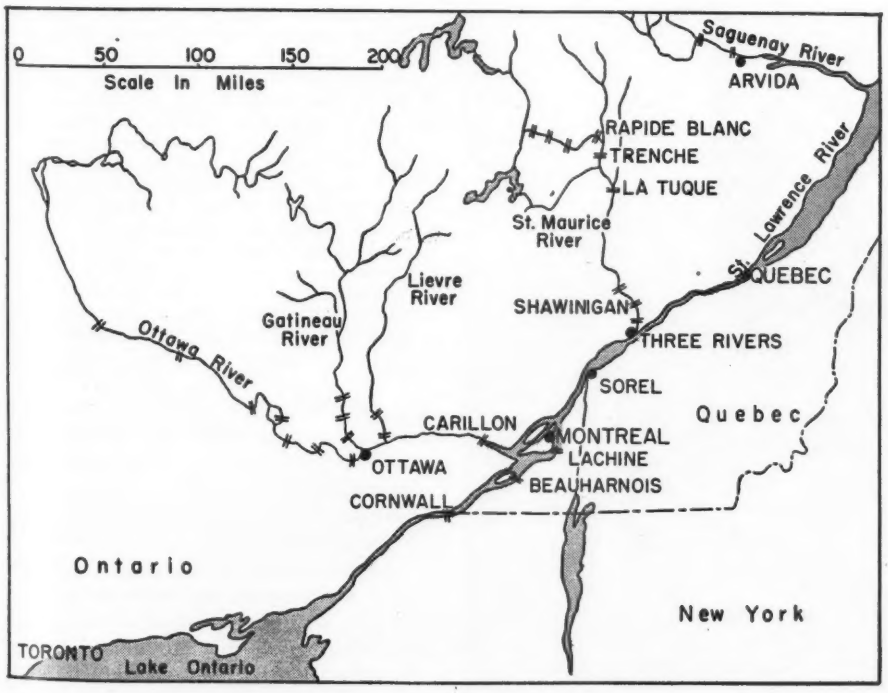
The Rapide Blanc station on the upper St. Maurice River that generates 200,000 hp. at 112 feet of head. Its capacity can be increased by 40,000 hp. by providing additional water-storage facilities at the headwaters of the stream.

At Lachine, which is not the equal of Beauharnois as to waterpower, the plan is to put a dam across the St. Lawrence at the foot of the rapids and to build dikes upstream on both sides to confine the river—these dikes to extend westward from the heart of the city for about 7 miles. There will be a head of 45 feet, and the installed capacity as proposed is 1,200,000 hp.

Like Lachine, the Carillon site will require long dikes to act as wings for the dam contemplated there. It is at a point on the Ottawa River 45 miles from Montreal and it is estimated that 400,000 hp. can be obtained from the 60-foot head. At present it seems unlikely that development will have to be undertaken in the near future.

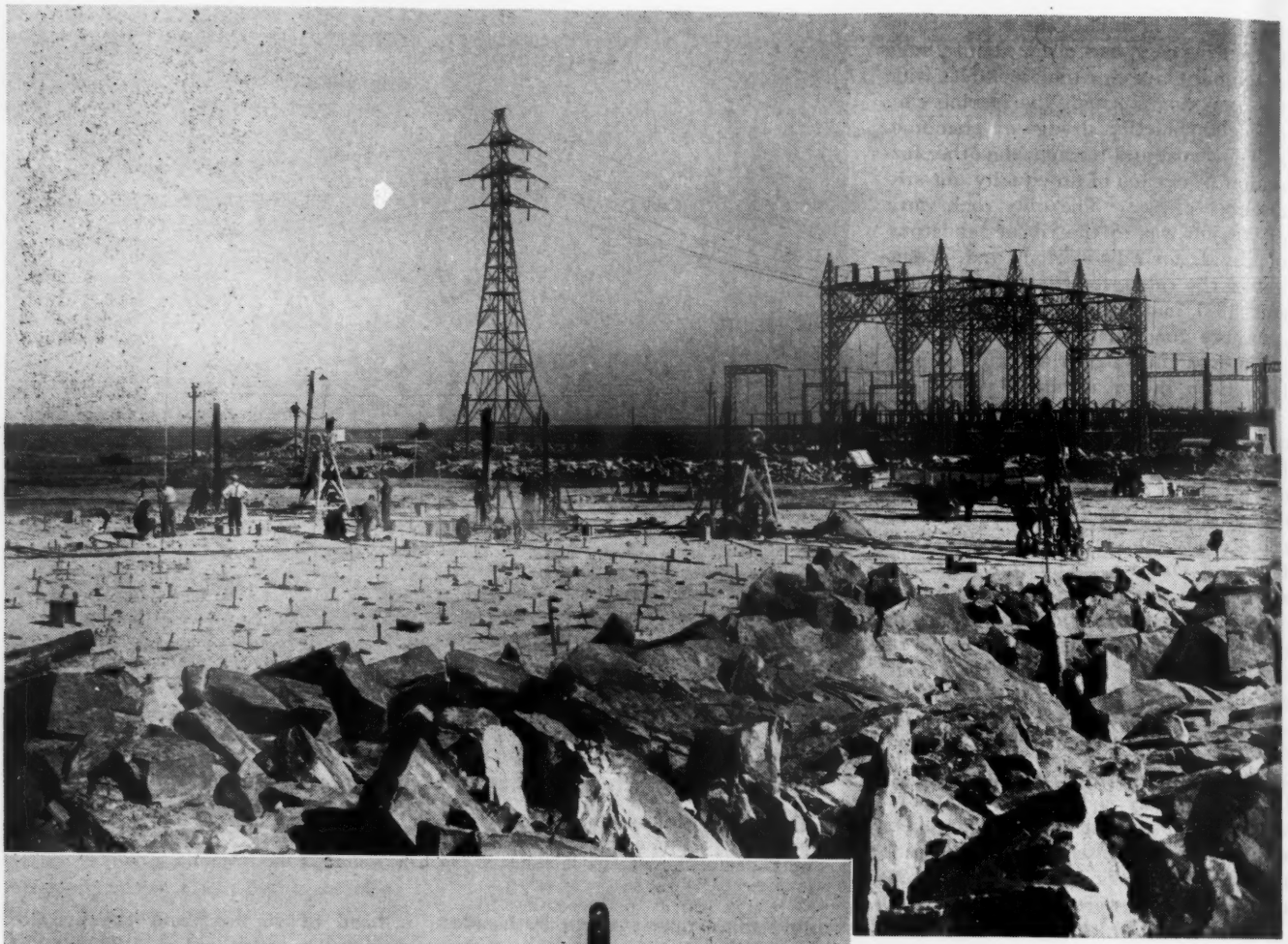
The foregoing description of the larger hydroelectric sites will serve to indicate the abundance of the power resources in the Montreal area. The aim of the Shawinigan Company and of Quebec Hydro is to keep sufficient generating capacity in reserve to provide against possible periods of subnormal precipitation. Any surplus available is used to raise steam in electric boilers, thus saving coal, all of which must be imported.

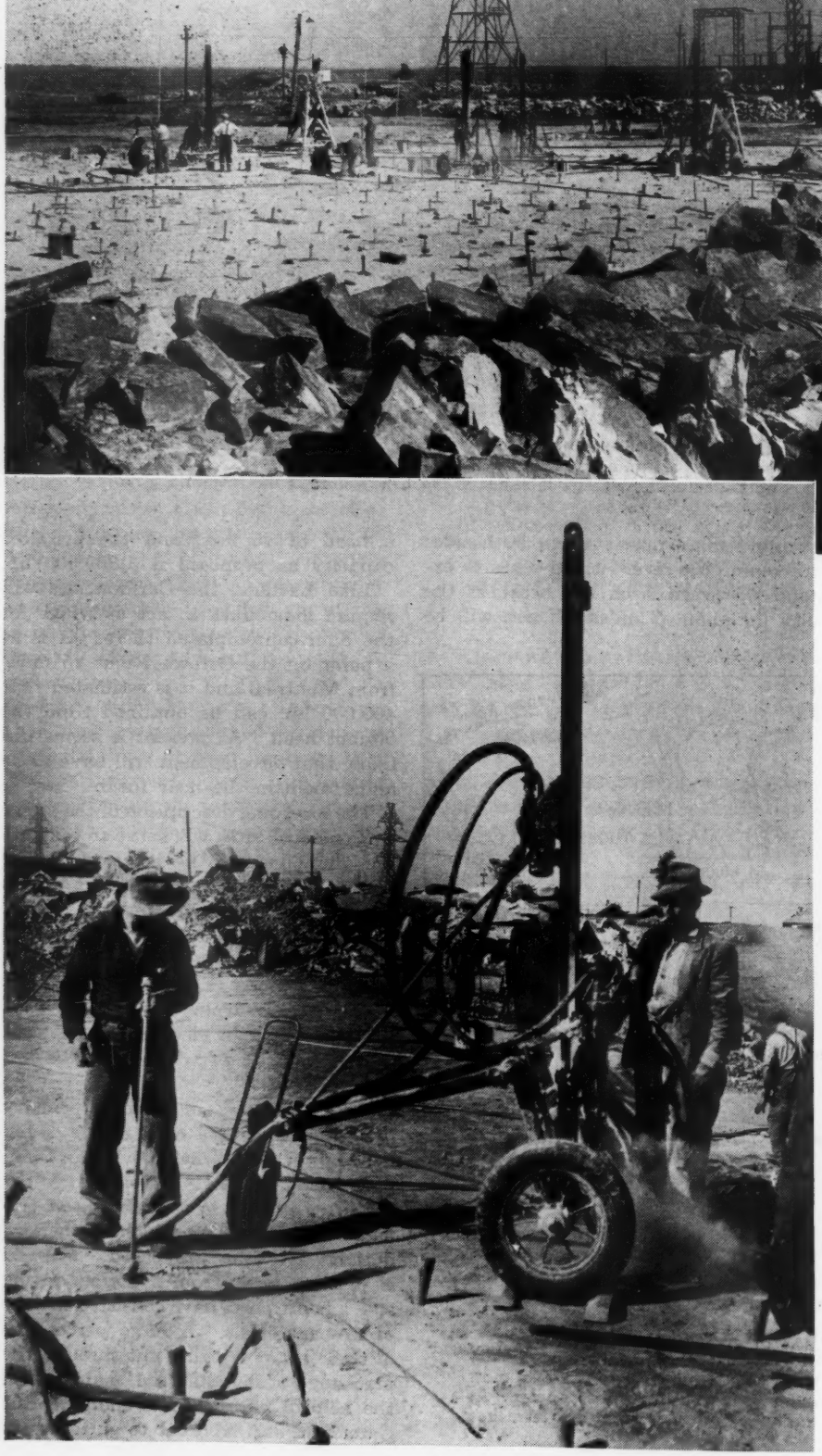
Now for a glance at the great primary industries that take most of the developed power. Both the Shawinigan Company and Quebec Hydro encourage the use of electricity in the making of primary products upon which further industrial activities are based. Canada is just emerging from a period during which her exports have consisted mainly of raw materials. A large percentage of these are now being put through the first stage of manufacture, mainly with the help of hydroelectric energy. But Canadians still have far to go to attain



POWER SITES FARTHER AFIELD

More than 12,000,000 hp. of hydroelectric energy can be generated by developing all the sites indicated by double bars. The paper mills of Quebec, most of which are within the area shown, consume about a million horsepower. At Arvida, in the upper right-hand corner, is the huge Shipshaw plant that furnishes power for producing aluminum.





DRILLING AT BEAUHARNOIS

A canal 3000 feet wide and 14 miles long is being excavated alongside the St. Lawrence River to carry water to a 700,000-hp. generating station under construction at Beauharnois. A ridge of quartzite at the downstream end resulted in a drilling problem, the material being extremely obdurate and highly wearing on ordinary bit gauges. After trying various types of equipment, the contractor adopted Ingersoll-Rand DA-35 and DA-30 drifters on wagon and Wagonjack mountings. Carset bits of 2-inch gauge are employed. The general scene (above) shows blasted material in the foreground, loaded holes beyond it, and drills in the background. The other picture gives a close view of a JHM Wagonjack drill rig at work.

the final stage in which the primary products are converted into finished articles that people buy. This stage, too, will be aided greatly by waterpower. However, we shall confine our attention to the former.

More than half of the country's paper and paper products are made in Quebec, and pulp and paper mills consume more hydroelectric energy than any other single industry in Canada. In the area under discussion there are ten large mills and as many smaller ones using not far short of a million horsepower. Their annual output of paper and pulp for the market is at present worth in excess of $160,000,000. Most of it is

sold in the United States, where it helps to pay for coal, oil, cotton, and other raw materials that Quebec cannot produce. The forests of the area tributary to and supplying these mills are being used to the utmost—there is no room for expansion. The position of the paper business of the region can therefore be considered stable.

In 1900 the first Canadian aluminum reduction plant, and one of the first in the world, was built at Shawinigan Falls on the St. Maurice River. It was placed so close to the powerhouse that direct current was generated and transmitted to the furnaces, a few hundred feet away. Those old pot lines were operated throughout the recent war, but have been dismantled since then in favor of a modern station on the outskirts of the town. While much smaller than the giant plant at Arvida, 150 miles to the north, the present one at Shawinigan Falls would be considered large anywhere. At La Tuque, farther up the St. Maurice, and at Beauharnois are wartime pot lines of substantial size not now in use but available in case of emergency. Those at Ile Maligne may be considered tributaries of the main station at Arvida.

It is not likely that additional aluminum plants will be put up in this part of Quebec. In fact, during recent months Aluminum Limited, the firm that controls all the Canadian subsidiaries, has been examining the Pacific Coast in British Columbia for a site where a large block of energy could be made available. Several possible sources are located there, each of which could furnish nearly as much power as the Saguenay River. In fact, British Columbia takes second place among the provinces in the matter of potential waterpower, Quebec being well in the forefront.

Another of the early activities at Shawinigan Falls is that of the Canadian Carborundum Company, which still has the distinction of operating the largest plant of its kind in the world. Carborundum, the first artificial abrasive, is one of the most widely used, especially since it was found to be useful as a high-temperature furnace lining and as an electrical-resistor element for heating purposes.

One of the most interesting as well as profitable basic industries of the area is the manufacture of synthetic chemicals at Shawinigan Falls. It was started in a simple way 50 years ago making calcium carbide out of limestone and coke. At that time there was an expanding market for acetylene lamps, first for service in buildings and then in mines, and for a while, believe it or not, in the headlamps of early automobiles.

During World War I the possibility of acetylene as a base for more complicated compounds was explored by producing acetone, an ingredient in the British military propellant cordite. Acetone had been obtained mainly from Germany. Need for it was urgent, and was met after several months of hectic and heroic research by a group of young chemists and engineers at Shawinigan Falls. Acetic acid was decomposed to provide acetone, which found a ready market in industry when peace was declared. Numerous other chemicals such as acetaldehyde and crotonic acid are among the family group derived economically from acetylene, and there is a demand for each.

One of the important products at present is acetylene black. Carbon black with unique properties, it is made by the decomposition, almost quantitatively, of acetylene, with hydrogen as a by-product. The hydrogen is piped from Shawinigan Chemicals to the adjoining plant of Canadian Industries Limited, where it is combined with chlorine to give hydrochloric acid or, more strictly, the dry hydride of chlorine. Some of the latter is piped back to Shawinigan Chemicals for the making of vinyl-acetate resins—a series of plas-

PAPER-MILL CENTER

Three Rivers, the leading paper-making city in Quebec, as seen from an airplane. The mills consume large blocks of hydroelectric power. In the foreground are the St. Lawrence Paper Mills situated on the St. Lawrence River just upstream from its junction with the St. Maurice, which is visible in the background.

tics called Vinylite—ranging from one of varnish-like consistency through chewing gum and rubbery compounds to the popular hard plastics that have innumerable applications.

There is still much in store for this great chemical and hydroelectric center through the chemist's wizardry. For the profitable production of ferroalloys it is necessary to have plenty of low-cost power; and for ferrosilicon it is equally vital to have cheap and pure sandstone. Both are available at Beauharnois, the little old French-Canadian town on Lake St. Louis after which the canal and power plant are named. As noted previously, the ridge of rock on which the powerhouse head block is set is composed of sandstone. It is almost pure quartz and eminently suitable for the needs of nearby St. Lawrence Metals & Alloys, which was founded at that strategic point in 1936. Its standard products are ferrosilicon, of 50 and 75 percent silicon, and 98 percent silicon metal.

The plant is equipped with thirteen electric furnaces with a total input of 64,000 kw., small furnaces having been found to be most economical for the purpose. For ferrosilicon, the charge consists of a mixture of crushed and sized sandstone mixed with coke for reduction, and of iron turnings and borings to furnish the "ferro" part of the alloy. Lately, the high cost of this low-grade scrap has compelled the use of iron ore as a substitute. For silicon metal, the iron is left out. The annual capacity of the St. Lawrence Metals & Alloys plant is 75,000 tons. The amount of each product consumed in Canada is small, so most of it is exported to overseas markets.

The latest and by no means the least interesting of the electrometallurgical projects of the Montreal district is that initiated recently by Kennecott Copper. In 1946 the company's prospectors, searching in a little-known area of the lower St. Lawrence where some small deposits of titanium ore had been located, found a body of ilmenite that has turned out to be the world's largest single deposit of which there is knowledge. Kennecott, in association with New Jersey Zinc, was already at work on a new process for treating this ore for the recovery of its iron and titanium-dioxide content. The major mineral discovery at Allard Lake, 22 miles north of the fishing village of Havre St. Pierre 600 miles northeast of Montreal, hastened plans for a treatment plant.

Sorel, on the south shore of the St. Lawrence at a point 40 miles below Montreal, has been selected as the site because it is midway between two sources of power. A contract has been made with the Shawinigan company for 150,000 hp., and energy is expected to be available upon completion of the Trenche powerhouse in 1951. The latter will supply the first unit of the electric-furnace plant, which is laid out with a view to expansion to four times the initial size, which will require 1500 tons of ore a day. It is expected that additional power can be obtained when necessary from Beauharnois, or possibly from Lachine, to bring the total to 500,000 hp.

The capacity of the first unit at Sorel has been determined more or less by the amount of refined titanium dioxide that present markets can absorb. When titanium metal can be produced economically for general industrial purposes, the plant will no doubt be enlarged rapidly to its maximum size. The new method for treating ilmenite differs radically from the one now in use, which depends upon sulphuric acid to dissolve out the iron (which is wasted) and then to refine the titanium dioxide. At Sorel, the iron will be reduced to metal in large electric furnaces and sold. The residue or slag will constitute high-grade ore of titanium containing 70 percent titanium dioxide suitable for the present purification process or any other that may be developed.

A railway, 27 miles long, is now under construction from Havre St. Pierre to Allard Lake. The line and the mining operation at the lake are controlled by a subsidiary, Allard Lake (Quebec) Mining Corporation, and the smelting plant at Sorel will be under another subsidiary, Quebec Iron & Titanium Corporation. In view of all this it is likely that the Montreal area may soon become the main source of the world's supply of titanium dioxide and see the first large-scale commercial production of the new base metal titanium.

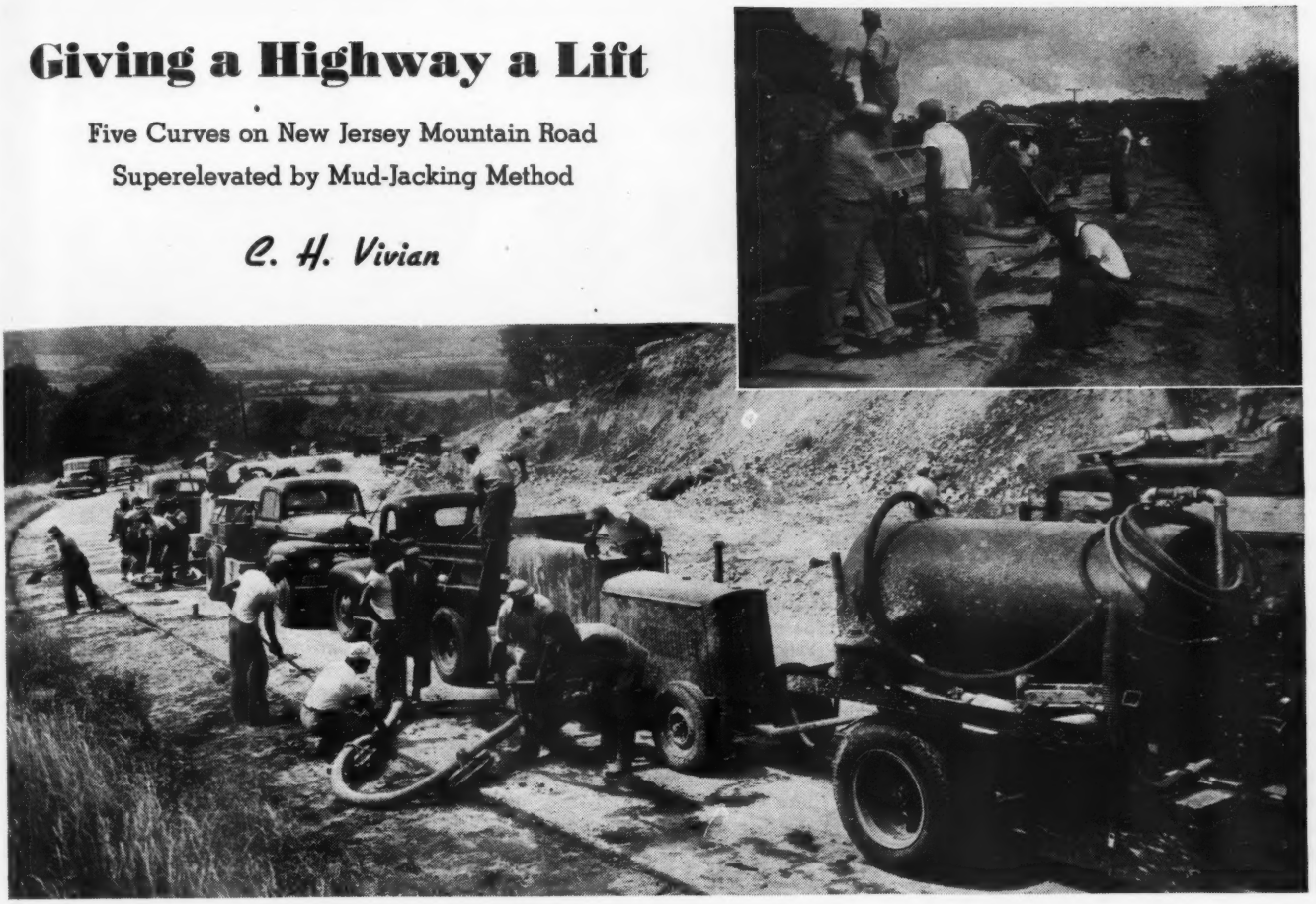
SHAWINIGAN CHEMICALS PLANTS

Here, on the St. Maurice River, are turned out chemical products of great variety. The cars on the railway sidings contain coal and limestone, which are combined in electric furnaces (marked by a cloud of fumes) to make calcium carbide. Water is added to the latter to produce acetylene gas, and the spent calcium hydrate is stockpiled for possible future use (white area on edge of river). In the buildings in the center and at the right the acetylene is converted into several useful chemicals. The group of large structures at the bottom, just left of center, is the plant where Vinylite plastics ranging from varnish-like and rubbery compounds to hard materials are produced.

Giving a Highway a Lift

Five Curves on New Jersey Mountain Road Superelevated by Mud-Jacking Method

C. H. Vivian



MUD-JACKING IN PROGRESS

Two complete crews are shown injecting mud under the outer edges of concrete slabs being elevated. In the lead is a water tank, followed by a Mud-Jack pumping unit and, behind it, a truck from which dry-mixed material is being shoveled. Mud is being pumped through the hose. The wooden supports or "skates" placed under the hose at two points facilitate pulling it around and reduce wear through abrasion. At the top is a close-range view of the injection equipment, with two men standing on the circular plate to keep the nozzle in the hole. Mud may be seen issuing at the edge of the concrete, which has already been lifted the height of the vertical face that shows.

THE mud-jacking method of raising sunken pavements has been used by the New Jersey Highway Department since 1933, or shortly after its introduction in the Midwest. During the intervening years it has proved itself to be highly adaptable. So many jobs now arise where it can be applied to advantage that the department's available equipment is unable to handle them promptly and there is a sizable backlog of work awaiting attention.

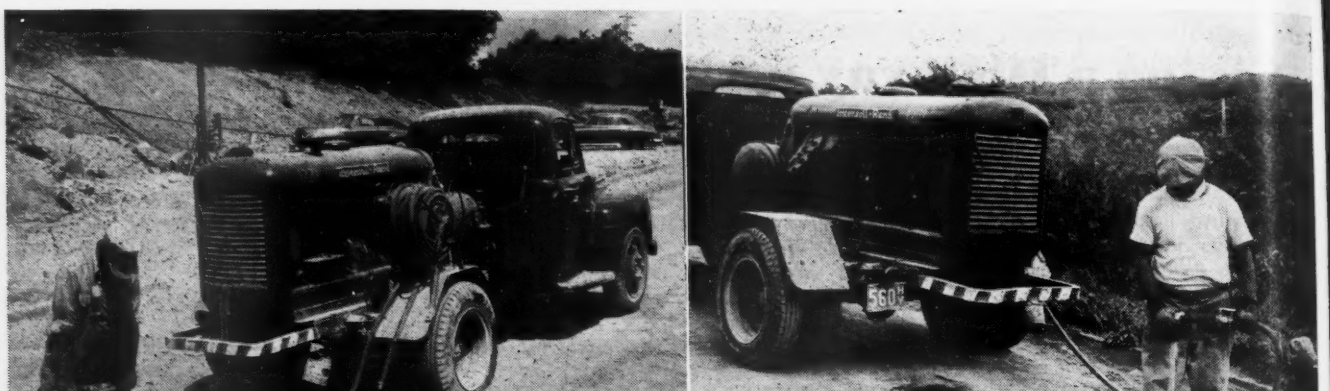
The original purpose of mud-jacking was to correct unevenness in concrete highways by pumping a fluid soil-cement mixture under affected sections to restore proper grade, and much of the New Jersey work is still of that nature. In addition, mud-jacking is being used increasingly to superelevate curves on existing concrete highways that were constructed when average motor-vehicle speeds were considerably lower than they are today.

A job of the latter type was carried out recently in connection with the widening of a stretch of U. S. Highway 22-N. J. 28 about 12 miles east of Phillipsburg, N. J. This is part of a program that was launched several years ago to convert the 2-lane, 2-way road into a 4-lane, divided expressway throughout the 60-odd miles of its length that crosses New Jersey from Jersey City to the Pennsylvania border. Approximately one-half of that stretch has already been rebuilt.

The section under consideration crosses Jugtown Mountain just east of West Portal, so named because it is near the western end of the Lehigh Valley Railroad's Musconetcong Tunnel that passes through that mountain. There the highway attains its highest elevation in New Jersey. It negotiates the mountain by means of a winding course, the curvature being greatest on the western side, which is the steeper of the approaches. Being a main thoroughfare westward to Pittsburgh and beyond, Highway 22-28 is heavily traveled by both passenger cars and trucks. As the latter can make the Jugtown climb only at low speed, this particular stretch has long been an annoying traffic bottleneck, often congested by lines of slow-moving cars and impatient drivers. It has, understandably, produced its share of accidents, especially during the winter season when ice and fog added to the hazards.

Reconstruction, involving 1.6 miles, is under contract to A. J. Cunningham & Sons, of Trenton, N. J. Because of the importance of the route, it was stipulated that the job must be completed in 90 working days. Meanwhile, traffic is being diverted over other roads. The work is being done in such a manner that the existing 2-lane concrete strip will be incorporated in the finished roadway. The new section will be of bituminous-concrete construction and, to provide uniformity, the old strips will be similarly black-topped. In preparation for this finishing treatment by the contractor, the state highway forces have elevated the curves.

This piece of road was built in 1921-22 and has withstood the effects of heavy pounding exceedingly well. The concrete is 8 inches thick, with steel reinforcing mats at two levels. It is divided at the center by a joint and a strip of embedded steel into two lanes, each 10 feet wide. Each lane is made up of slabs running 124 feet between joints, which is considerably longer than they



DRILLING AND BLOWING A HOLE

One portable compressor served up to three mud-jacking outfits at the height of the operations. Truck-mounting gives the 210-cfm. unit high mobility. Back of the cab is a tool chest for carrying two drills and a paving breaker. The reel of hose permits reaching working locations a considerable distance away. These views illustrate the two principal uses of compressed air: drilling (at the left) and hole-blowing. In the latter picture note the circular shield on the air pipe. This disk protects the operator from flying stones and dust.

are currently constructed. On each side of the highway proper is a 5-foot-wide concrete shoulder for drainage purposes, flanked by a concrete curb.

The designers specified little or no elevation on curves. In fact, the general scheme was to make the centerline 2 inches higher than the outside edges to insure drainage to both sides. In the reconstruction, a uniform slope across the 20-foot surface from the outer to the inner edge of curves is being provided. This has entailed elevating the outer edges anywhere from 2 to 13½ inches, depending upon the degree of curvature specified for the section concerned. To obtain the desired uniform cross slope it has, of course, been necessary to elevate the intermediate sections between the outer and inner edges lesser amounts progressively.

Involving merely the drilling of holes through the concrete and injection of a prepared fluid mixture under pressure, the process of mud-jacking is essentially simple. The drilling is routine and readily accomplished with standard rock drills. Efficient injection equipment has been developed by the Koehring Company, of Milwaukee, Wis. These mechanical accessories can be depended upon to function satisfactorily, but the all-important element in a mud-jacking job is experienced supervisors and crews. Knowing such things as where to place the holes, how to space them, what composition of mixture to use, how fluid or stiff to make it, the best order of injection through the series of holes, how much material to inject at a time—all these are of vital importance.

These factors and others vary according to local conditions, and the ability to make the proper decision regarding any of them can be acquired only by actually dealing with them many times. In the course of sixteen years of utilizing the method, the New Jersey Highway forces have come by this essential know-how and can now look over a given job and plan the procedure with the assurance of achieving satisfactory results.

In this instance, holes 7 feet apart were drilled in a line the length of the outer slab and 30 inches in from its outer edge. The end holes in the line were located 36 inches from the transverse joints. Where the inner edge of the slab was also to be raised a considerable amount, a corresponding row of holes was put in there, observing the same spacing as before. Injection started at an end hole on the outer edge and was carried progressively along the line. Enough material was put in initially to raise the affected area an inch or two. After the line of holes had been covered, the operation was repeated, using the same starting point as before.

If considerable elevation of the outer edge was called for, injection was shifted to the line of holes along the inner edge of the slab after the outer one had been given two or three lifts. As previously stated, determination of the proper sequence is a matter of experience and no hard and fast rules can be laid down or observed. It goes without saying that lifting the pavement too much in any one area before passing to an adjoining one will produce cracks.

The material used consisted of washings from a commercial sand-preparation plant and was a mixture of sand and an average of about 40 percent elutriable soil. In all mud-jacking operations, there is a limit to the amount of sand that can be used effectively. If there is too much of it, the water that is added to give fluidity will leave the mixture when it is injected and flow out under the pavement, traveling the paths of least resistance. The sand remaining behind then builds up around the bottom of the hole and bars further injection. A suitable proportion of clay is consequently necessary, and in this case a small quantity of lime was also added to improve flow characteristics or, as the crews put it, to make the stuff slick. Portland cement is always included to make the mud set, and here it amounted to 8 bags for every cubic yard of mud-jack material.

The mixture that has been described was prepared dry, a time-saving set-up for accomplishing this being located on the mountaintop. The sand-plant washings were stockpiled against a timber wall, forming a mound sloping away from it on one side. On top of the wall was stationed a Ransome 2-bag concrete mixer into which the earth was shoveled and the lime and cement dumped from bags. As shoveling reduced the pile, more material was pushed up its slope with a small bulldozer. The mixer discharged onto a screen of ¾-inch mesh, inclined so that stones, sticks, and clay lumps moved down over its end, while the screened material passed through and into a 1½-ton truck standing underneath. By means of a rope passing over a pulley on top of a post and attached to the lower end of the screen a workman could jiggle the latter to assist the screening process.

Water was added to this dry mix in the Mud-Jack immediately prior to in-

jection. The Koehring Model 50 used on this job is a compact unit consisting of a mud mixer, a mud pump, water-feed pumps, and a gasoline engine to drive them, all mounted on a 4-wheeled, pneumatic-tired chassis for towing. The dry mix is shoveled into a hopper that opens into the mixing chamber. At the same time, water is admitted under the control of an operator who stands on one side of the machine in an elevated position where he can observe the mixing and readily reach the water valve. He judges the consistency of the mud by eye, and adjusts the admission of water according to experience, or as directed from time to time by the men at the injection nozzle.

An auger-type, horizontal spiral blade revolving in the mixing chamber thoroughly works the water and dry material, moving the resultant mud along to a low baffle, over which it spills into the mud pump. The latter consists of dual vertical plungers, one on either side. As one rises, the other descends. On the upstroke, a valve opens and mud flows down through a central opening in the plunger. Below the plungers are chambers connected by a passageway containing a ball check valve that prevents material being pumped by one cylinder from rising under the opposite one during its upstroke. There are outlets for hoses on each side of the machine, and a 2-way valve can be obtained to permit pumping through two hose lines simultaneously. But in this instance only one line was used.

The drilling equipment consisted of an Ingersoll-Rand Mobil-Air 210-cfm. air compressor mounted on a truck, a JB-5 and a JA-55 Jackhamer, and a CC-45 paving breaker. Before a slab could be raised, it had to be broken loose from the abutting one at each end. To do this, a line of closely spaced holes was drilled along those joints and the intervening sections of concrete were broken out with the paving breaker. The injection holes were then drilled, using Jackbits of 2⅝-inch gauge on 14-inch drill rods. This produced holes into which the injection nozzle fitted snugly. The latter has a rubber nipple that expands when under the pressure of pumping to form a seal that prevents leakage.

Before injection was begun, each hole was blown out with compressed air to form a cavity in the ground beneath it to give the first mud introduced a place to go and to assist in starting its flow out under the slab. The blower pipe inserted in the hole had a curved end to direct the air outward and, with 100 psi. of pressure available, a pocket was readily excavated by turning the tool continually. Because the air blast ejected the displaced material up through the hole around the pipe, the latter was fitted with a circular metal shield to protect the operator from flying dirt and stones.

When pumping was started, the mud was thinned to assist its flow. Once it had begun to raise the pavement and spread out, the mixture was gradually thickened under the watchful eye of the Mud-Jack attendant. Pumping was continued through one hole until the mud began to come out of the hole third removed from it—a total distance of 21 feet.

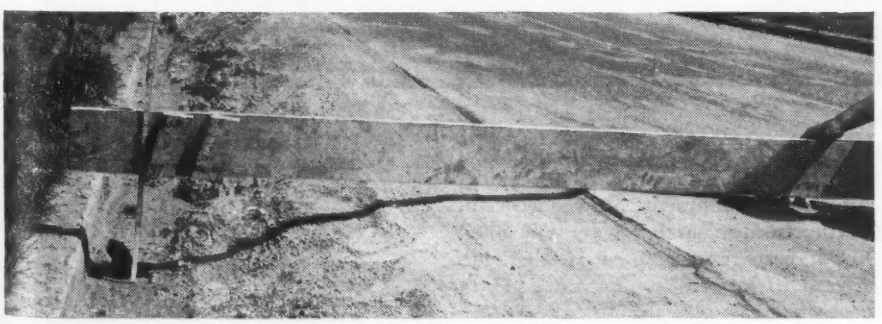
Little trouble was experienced in keeping injected mud from coming out at the joint between the slab and the concrete shoulder alongside so long as there was as much as 2 or 3 inches of vertical surface contact between the two, or until the 8-inch slab had been lifted 5 or 6 inches. When this height had been reached and the final elevation called for more pumping, clay earth was spread over the shoulder area and compacted, thus forming a seal that stopped most leakage. The shoulder is being retained on the side of the existing roadway that will be the outer edge of the rebuilt highway. Where it was in good condition, it was drilled and elevated in the same manner as the slabs were raised. Portions not in good shape were taken out and will be replaced with new concrete. The shoulder on the opposite side, in the center line of the widened thoroughfare, was broken out after the adjacent slabs had been elevated.

Water for mixing the mud was transported in 750-gallon truck-mounted tanks developed by the highway department. Each unit has a pump, driven by power take-off from the truck engine, for filling the tank. The water was obtained from springs at the western base of the mountain. The pump that fills the tank also serves to flush out the inside surfaces of the Mud-Jacks after each day's use because any of the cement-mud mixture left inside would harden overnight. At the rear of the tank is a ¾-inch outlet for making a hose connection to pump water to the Mud-Jack.

In operation, the equipment was drawn up in a line at the working site, with the air compressor in the lead. The latter was ordinarily engaged in drilling holes well in advance of the injection crews, but even then it was near enough to be run into position for blowing holes when necessary. Next in line was the water truck, which towed the Mud-Jack. Last in line was a truck containing the dry mixture, which was shoveled into the Mud-Jack as needed. At the peak of the Jugtown Mountain work, three tank trucks, Mud-Jacks, and dry-mixture trucks were in operation, with one air compressor serving all of them.

As an accompanying illustration shows, the injection nozzle passes through the center of a circular metal plate, which is flush with the pavement surface when pumping is in progress. Two men ordinarily stand on the plate to hold it down against the pressure of the mud from below. When pumping was started, it occasionally happened that too thin a mixture was employed, permitting the water to separate out and flow away, leaving the solid material behind to plug up around the base of the hole, as previously noted. In such cases, the blow pipe was brought into play to remove the impeding deposit so that injection could proceed normally.

Approximately 1000 cubic yards of mud was injected to elevate five major curves. The composition of the dry-mix material was checked in the department laboratory periodically, and samples of the mud after setting were tested for strength at regular intervals. The work was directed by Spencer Miller, Jr., state highway commissioner, through Alex. W. Muir, superintendent of maintenance. The exploratory and research efforts that were made preliminary to initiating operations were in charge of F. D. Woodruff, assistant superintendent of maintenance. The field work was in charge of M. A. Lanzara, superintendent of construction, assisted by George McCann as general foreman and Joseph Henry and Joseph Carr as maintenance foremen.



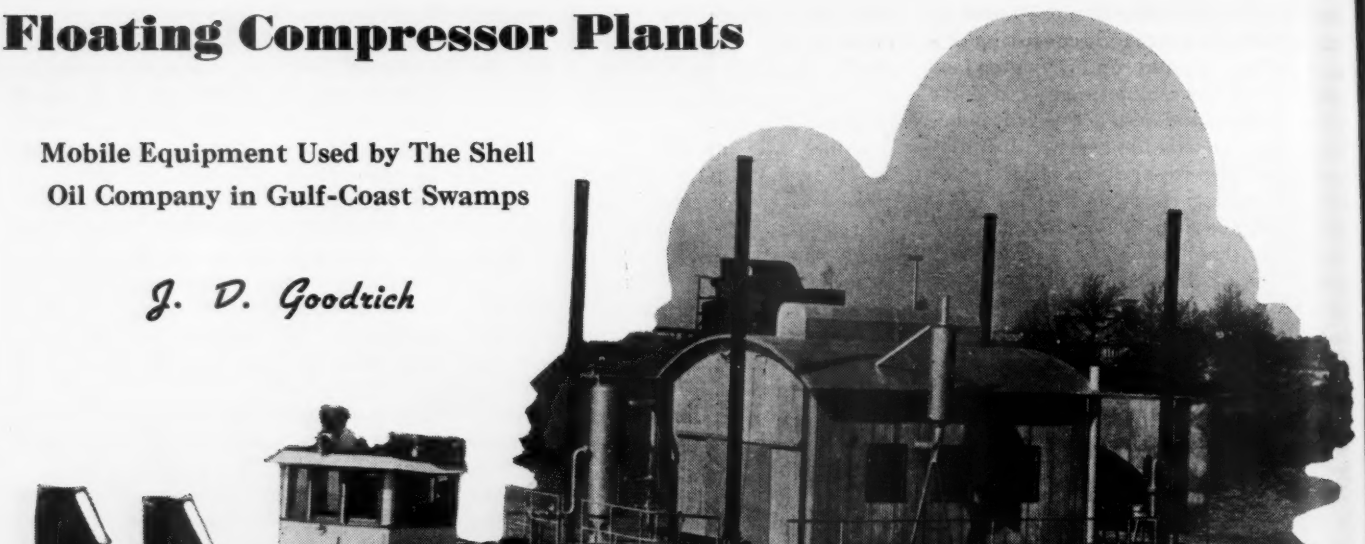
MAXIMUM LIFT

A section of highway where the outside edge has been raised 13½ inches, with a progressively lower elevation across the two 10-foot slabs to provide a uniform slope. The shoulder between the curb and the edge of the road has been filled in with clay to prevent injected mud from leaking.

Floating Compressor Plants

Mobile Equipment Used by The Shell Oil Company in Gulf-Coast Swamps

J. D. Goodrich



FIRST BARGE

Since it was built in 1946, this floating compressor plant has been in continual service. It contains one 225-hp., gas-engine-driven compressor. Its success led to the construction of a second and larger barge that is shown in another picture.

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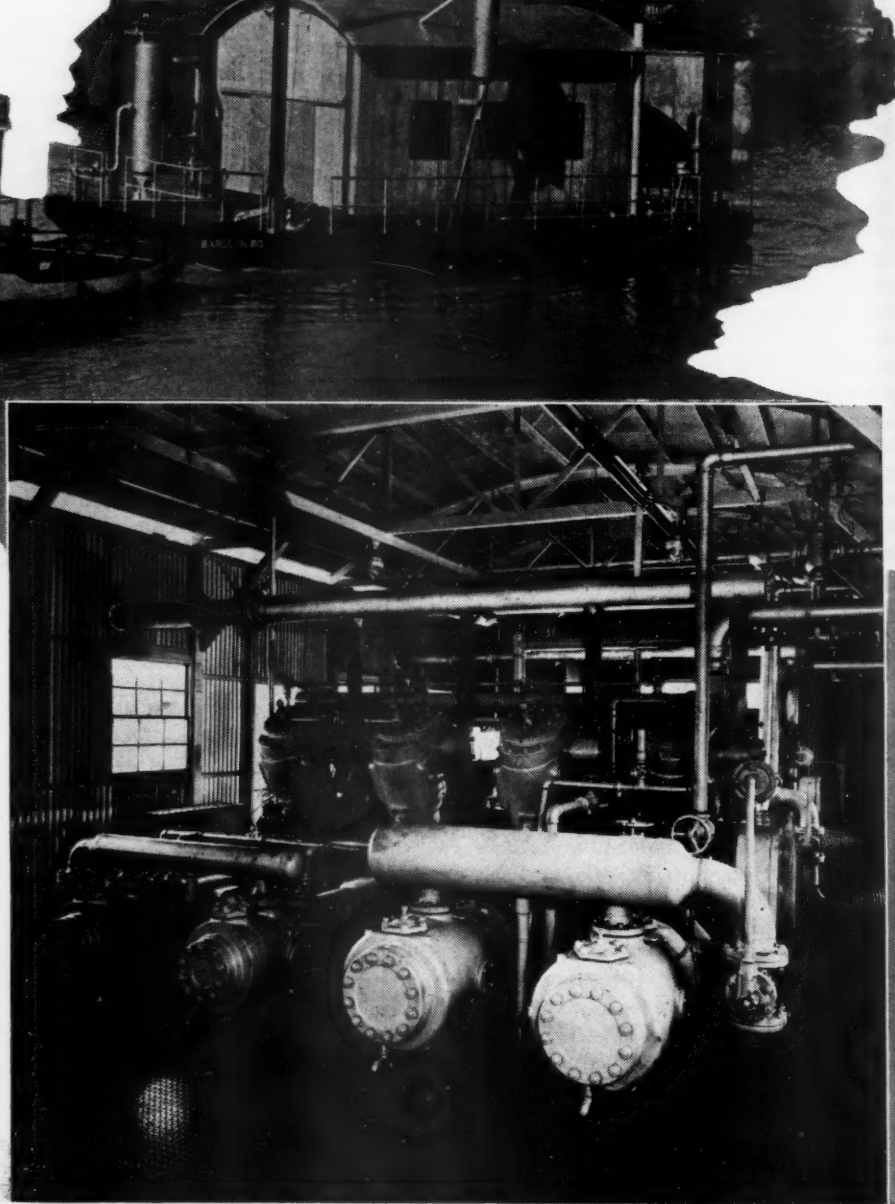


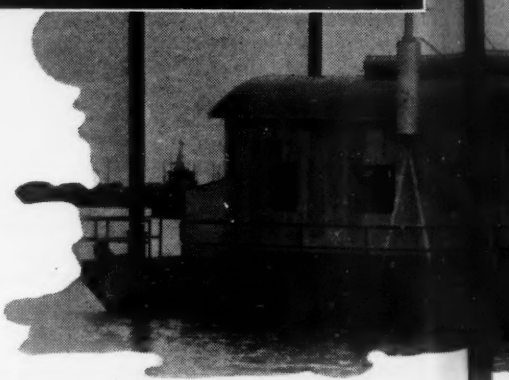
INTERIOR OF LARGE BARGE

Right, is an Ingersoll-Rand Type XVG 300-hp. gas-engine-driven compressor. A second, identical unit is directly behind it. Each machine is designed for an intake pressure of around 40 psi. and a discharge pressure of 600-700 psi. and will handle about 1,900,000 cubic feet of gas a day. The compressors are used to boost the pressure of gas obtained from oil wells so that it can either be employed for flowing wells by the gas-lift method or put into pipe lines for transmission to areas where it can be sold.

THE development of oil fields in swampy areas along the Louisiana Gulf Coast was, at one time, a rather expensive operation. Initially, drilling was done from piling platforms which were costly to erect as well as to salvage. The now familiar submersible drilling barge, however, has obviated the need of piling and reduced location costs to an acceptable figure.

Equipment for producing wells in such regions has not always kept pace with improvements in drilling machinery and methods. But progress has been made, and the development of a successful floating compressor barge by The Shell Oil Company represents yet another step forward in lowering operating costs in those areas.

Large gas compressors are required in oil fields for two usual reasons: First, to boost low-pressure gas to a sufficiently high pressure for use in gas-lifting wells; and, second, to boost low-pressure gas to



a point that will permit its transmission for sale or return to an underground reservoir. In the past, the equipment has been placed on piling foundations, or on islands or earth fills whenever the latter happened to be present or could be made economically. Aside from the cost of the foundations, however, these installations were always expensive on account of the inaccessibility of the sites to construction crews and machinery and supplies. For the same reason, salvage costs and intangible losses were always high. Thus, there was considerable need of better facilities on which to set up the equipment.

As a corollary of the development of an efficient submersible drill barge it was natural that attention should be directed towards the possibility of barge-mounted compressors. However, one departure was desirable. Instead of submerging the vessel, it should float, for (1) it could then be used in water of any depth so long as enough was available for flotation; (2) it could serve in areas subjected to periodic flooding without danger of inundating the machines; and (3) it would simplify and reduce construction costs and maintenance.

The first unit built consisted of a barge 40 feet long, 25 feet wide, and 5 feet deep on which was installed an Ingersoll-Rand Type 6XVG direct-connected 2-stage compressor, together with all auxiliaries. Thus, to utilize the unit, it was necessary only to connect the suction and discharge lines and go to work.

The barge was raked on each end and compartmented by a collision bulkhead at each end and by one central longitudinal watertight bulkhead. All bottom, side, deck, and bulkhead plating was $5/16$-inch thick, and sufficient transverse frames were provided to insure a vessel that would be capable of withstanding any vibration set up by the compressor. The size of the barge was determined not only by the physical dimensions required to mount the equipment but also with the thought in mind of keeping the vibrational movement within acceptable limits.

The unbalanced forces of the compressor were: maximum vertical force—primary nil, secondary 2280 pounds; maximum horizontal force—primary nil, secondary 4280 pounds; and couples, both vertical and horizontal, nil. Calculations, using these unbalanced forces, indicated that with a vessel of the aforementioned dimensions a maximum horizontal barge movement of 0.006 inch might be expected at a frequency of 700 vibrations per minute. Although it was believed that this amplitude might be objectionable, the craft was considered large enough because the calculations did not take into account the inertia of the water nor its capacity to dampen vibrations. Actually, when the unit was put in operation, the vibrations proved to be well within acceptable limits and did not exceed those experienced in most land plants.

The compressor was set up directly on the barge by means of babbitt pads beneath the bolt holes of the crankcase. This method has been found to be satisfactory and does not call for a machined crankcase base or foundation. The cooling-water system for the machine was of the thermostatically controlled closed type with the soft water and gas passing through open-type tube bundles at the stern. The raw-water pump was belt-driven from the compressor flywheel and took suction from the bow end. Discharge was through the spray tower in the stern of the barge. Starting air was furnished by a 3-hp. compressor equipped for automatic shutdown. The air receiver was mounted in the building trusses.

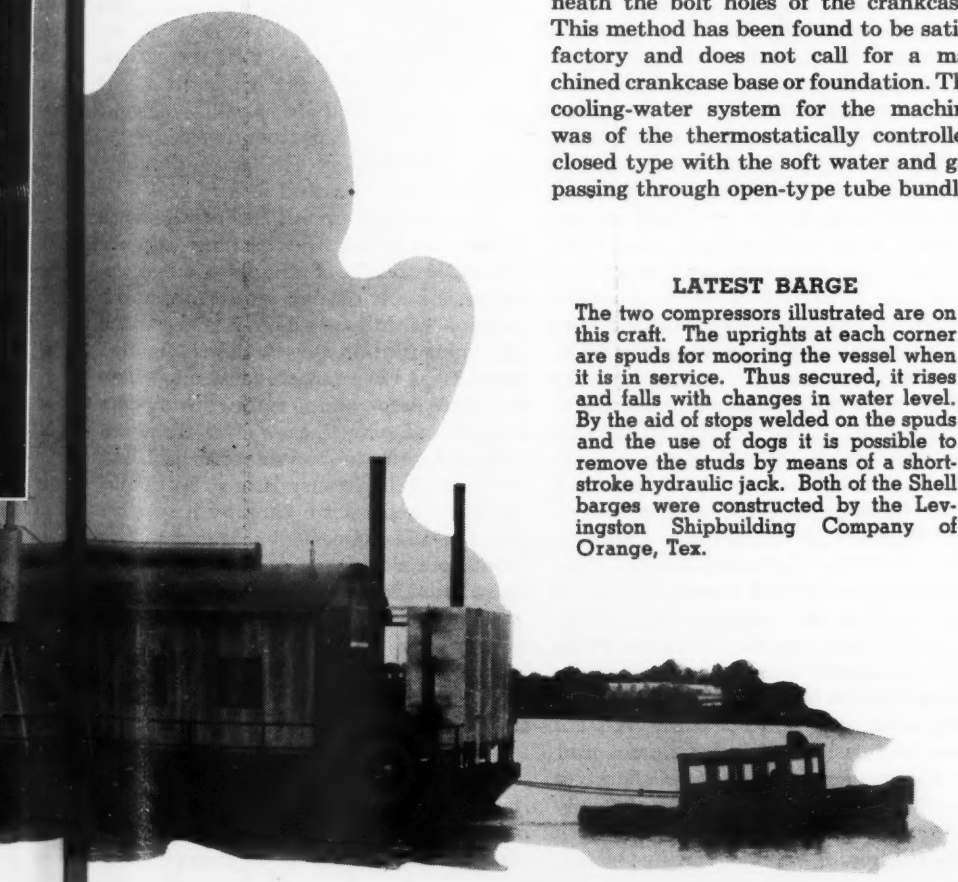
Inasmuch as the unit was designed for gas-lift service, it was equipped with a speed-pressure controller in addition to the conventional relief valves. For this type of work the controller is considered essential if the plant is to operate automatically—unattended.

Four spuds, one on each corner of the barge, were provided for mooring purposes. These consisted of 6.1x6.38-inch wide-flange beams around 25 feet long. Stops were welded on the spuds at suitable intervals and dogs were furnished to permit removing the spuds by a short-stroke hydraulic jack. When anchored, the vessel was free to ride on the spuds, thus allowing for any change in water level.

To insure shore connections of adequate flexibility, a conventional 6-inch oil-loading hose was used to bring the low-pressure gas (40 psi. gauge) aboard, while the high-pressure gas (750 psi. gauge) was taken back to shore through connections made up of roller-bearing sections. Both turned out to be entirely satisfactory and permitted the vessel to move short distances in any direction without danger of breaking the connections.

The compressor barge was put in operation in 1947 and proved to be so successful that a second one was constructed in 1948 for use in gas sales. It was patterned essentially after the first, the only basic difference being that it is 80x34x6 feet in size and that it has two 300-hp. compressors. Thus, the vibrational effect of multiple units on a floating barge could be determined. This plant was completed and put in service around the middle of 1948 and is also giving a satisfactory account of itself. In operation, the vibration is approximately the same as that in the first (single-compressor) barge and also well within acceptable limits.

The development of these floating plants has answered a definite need in the case of oil fields located in remote swampy areas where suitable foundation soils are nonexistent and where ingress and egress can be had only be water. Among their apparent advantages are: 1, they can be built at convenient points where construction equipment and labor are readily available; 2, they can be salvaged in their entirety; 3, they can be easily moved around a field as areas requiring high-pressure gas change, thus eliminating the cost and the horsepower losses associated with long suction and discharge lines.



LATEST BARGE

The two compressors illustrated are on this craft. The uprights at each corner are spuds for mooring the vessel when it is in service. Thus secured, it rises and falls with changes in water level. By the aid of stops welded on the spuds and the use of dogs it is possible to remove the studs by means of a short-stroke hydraulic jack. Both of the Shell barges were constructed by the Levingston Shipbuilding Company of Orange, Tex.

Capturing Copper from Mine Water

Arthur Hoem

THE OLD, HARD WAY

Their feet protected from the acid water by rubber boots, men are shown wielding stiff brooms to sweep the copper precipitate from old rails laid in a sluiceway. This slow, inefficient, and laborious method has been replaced by the mechanized apparatus shown in the other pictures.

HYDRAULIC SLUSHER IN ACTION

The electrically driven car, containing a centrifugal pump, travels on rails laid between two adjacent launders, spraying water under high-pressure into both sluiceways to remove the copper deposit from shredded tin cans. As it reaches the end of the tracks, it automatically reverses its direction. Consequently, it shuttles back and forth without supervision. The pump takes suction through the curved pipe that extends downward into a narrow launder adjacent to the right-hand rail.

DILAPIDATED, rickety, crate-box wagons filled with discarded tin cans and each usually drawn by a dirty white horse were familiar sights on the streets and alleys of Butte, Mont., about 40 years ago. Those vehicles found their way to East Butte and Meaderville, where their owners sold the cargoes to some 30 precipitating and waste-dump leaching plants then in operation along Silver Bow Creek.

Mine waters leaching through old workings and gob or stope fillings that have been exposed to the oxidizing action of air become enriched with copper in the form of copper sulphate. When waters flow through areas where sulphide ores have burned and have been extinguished they become remarkably enriched. If iron is placed in these cupriferous waters, the copper is replaced by the iron and is precipitated in the form of a spongy scale known as cement copper. This principle has long been applied by mining companies to extract copper that would otherwise flow away.

The earliest known application of the process was in the fifteenth century at the famous sulphide deposits of Rio Tinto, Spain. It was later used in the copper mines of Peru. The method was not adopted in the Butte area until November, 1889, when it was discovered quite by accident that the mine water contained copper. An attempt to extinguish a fire in the St. Lawrence Mine by flooding the workings proved unsuccessful because the water flowed into adjoining, connected mine openings. When the water was pumped out it was found to be rich in copper sulphate. No effort was immediately made to recover it, and the water ran off in an irrigation ditch.

A man named Miller, who owned property through which the trench passed, dumped scrap iron and tin cans into the stream and obtained a precipitate which he sold to a local smelter. Later he built flumes and settling boxes, and even though his plant was small it was profitable. The following year, Anaconda Copper Mining Company granted Bill Ledford the right to the water pumped from the St. Lawrence Mine. His initial outfit consisted of holes in the ground connected by a ditch and filled with scrap iron and tin cans. After a time he turned to wooden flumes and made considerable money. Others got into the business, and by 1910 virtually all copper-bearing waters flowing down from the mining area were being treated.

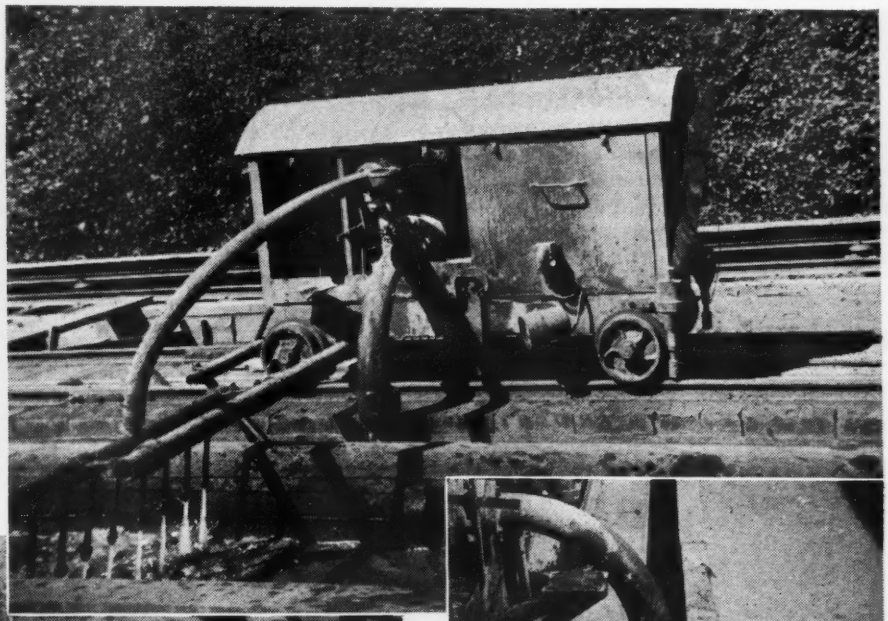
As mining properties became consolidated, precipitation plants were also combined, independent operators became fewer and fewer, and leases on copper-bearing water were difficult to obtain. The mines, except for a remote case or two, did the work themselves and used their abundant supplies of scrap iron rather than tin cans. The precipitation process then changed gradually, using launders instead of drip tanks.

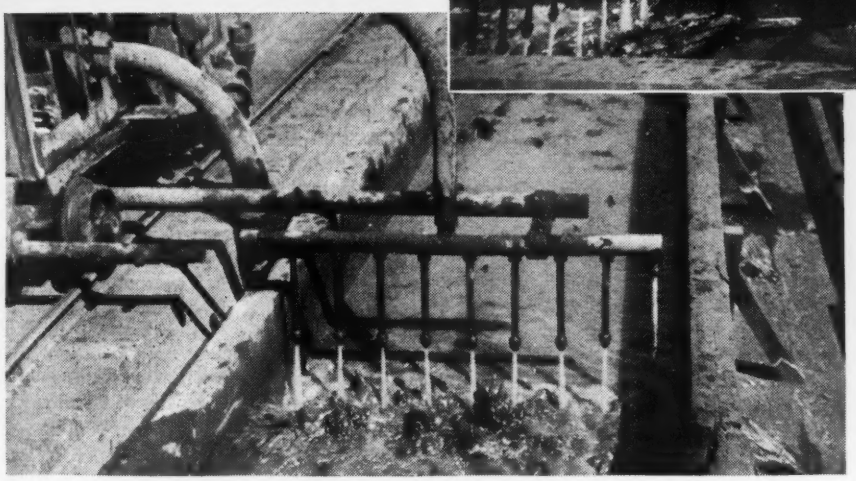
Today there are but two precipitation plants in Butte, the Leonard and the High Ore plants of the Anaconda Company. Each receives water from the High Ore Mine, which is the central pumping station for all the Company's workings. For years these launders have utilized scrap iron from the various mines and plants, as well as discarded railroad rails purchased from different sources. The former is now being furnished shredded tin cans by a supplier on the West Coast, but the latter is continuing to use scrap iron and railroad rails. Near completion is a modern precipitation plant of 5000-gallon capacity that will take the place of the obsolete Leonard and High Ore plants.

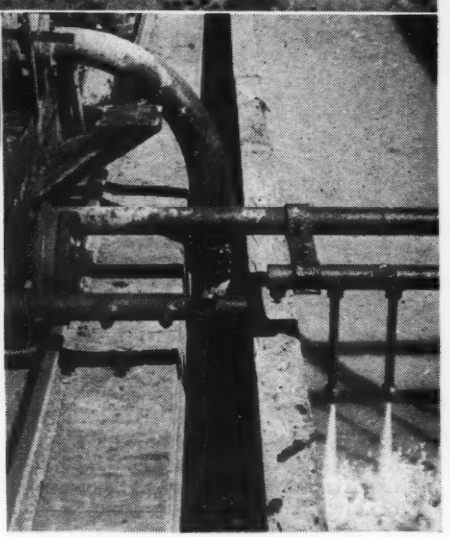
In order that precipitation of copper from mine water may take place as rapidly as possible, it is necessary that the cement copper be removed at regular intervals to expose clean iron to the action of the mine water. This was formerly accomplished by sweeping the

DETAILS OF EQUIPMENT

At the lower-left is a close-up of one set of jets, showing the turbulence created by the high-pressure streams impinging on the shredded cans. The picture at the lower-right shows the pump suction pipe extending into the launder from which it takes water through a specially designed footpiece. The side view of the car (just below) shows some construction details and a part of the pump. The object at the left of the right-hand wheel that resembles a flowerpot laid on its side is an electric light to illuminate the suction launder at night. A reserve supply of shredded cans is in the background.







deposit off with special brooms wielded by a sweeper crew. This method removed the copper only from the accessible surfaces of the iron, which in most cases represented about 50 percent of the total. For this reason, and also because of the drudgery involved, a better means of doing the job was sought. Several schemes were tried with varying success. All were based on the principle of hydraulic sluicing.

The machine that was finally adopted consists of an electrically driven car or slusher running on rails located centrally between two parallel launder sections. On this car is mounted a special-alloy RVH-10 Motorpump rated at 250 gpm. under a 100-foot head. There is also a gear motor which drives all four wheels through chains and sprockets. Power is picked up through a slot midway between the rails. Beneath and on each side of the slot are three wires which feed current through the medium of trolley wheels carried on a bracket that is attached to the car frame and rides in the slot.

The pump picks up its water from a narrow launder, on a 2 percent slope, that occupies a part of the precipitation launder section and is adjacent to the track on which the slusher travels. Since the suction pick-up conditions are far from favorable, great care was taken to insure smooth flow to the pump. An 18-inch-radius, 4x3-inch reducing ell was cast of acid-resistant bronze, and to the 4-inch or lower end was connected a special stainless-steel foot valve by hose and clamps. This boot-shaped valve has a screen of ample area on the upstream or toe side and is shaped so that the flow of the water is directed vertically along a smooth, curved bottom plate.

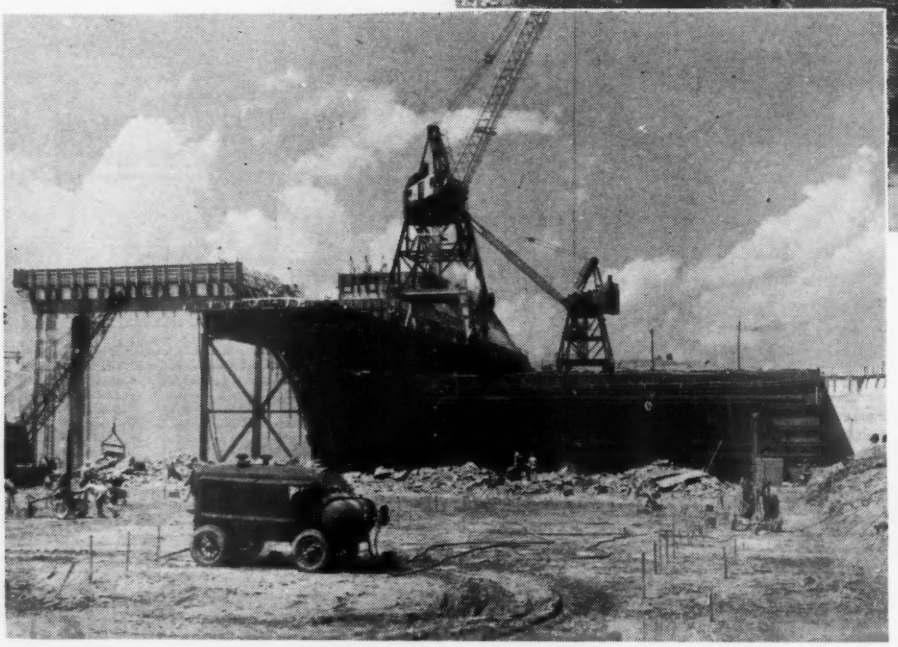
In operation, the slusher pump is primed and started. Water is then delivered to either of the launders through a header having several ⅜-inch jets. The traction motor is next put in service, and the slusher proceeds downstream at the rate of 14 feet per minute, the jets agitating the water in the launder and also impinging directly upon the iron. When the machine has reached the lower end of its run it is automatically reversed and retraces its path. It continues to move back and forth in this way so long as the operator desires, requiring no attention beyond the initial priming and starting of the pump and directing slushing to either launder by means of a stainless-steel 3-way valve.

Apparently the slushing action is as effective on tin cans as on rails. The turbulence induced by the jets in the precipitation launder gets at all surfaces of the rails and effectually removes all cement copper. In the case of tin cans, it is sufficient to roll them along and to reach to the bottom of the launder, as is evidenced by the fact that no cement copper is found there during clean-ups.

Whitney Dam

Texas Structure Will Arrest Brazos River Floods and Store Water for Generating Power

L. A. Luther



DRILLING FOR EXCAVATION

Wagon drills, top, putting down blast holes for removal of rock to foundation grade. They are powered by air from two 500-cfm. portable compressors. One of the latter units is shown in the lower picture with a section of the partly completed concrete dam in the background.

TEXAS rivers hardly seem to measure up to their state's tradition of bigness, but the several modest streams that flow in a more or less southerly direction to the Gulf of Mexico have nevertheless had a larger role in the state's development than their lengths and breadths warranted. In the era of early settlement, their function as meridians marking gradual penetration of venturesome Americans across a Spanish-speaking frontier is attested to by such references as "west of the Sabine," or "west of the Brazos," or west of that canyon-carving desert river, the Pecos, in a land of cactus and mesquite where Judge Roy Bean proclaimed himself the law.

Before the existence of primitive Texas highways such as the San Antonio Trace, the state's rivers served Spanish explorers as routes into the interior, and continued to be used by early American settlers. Texans have never been indifferent to their waterways and have done big things with small beginnings; witness Houston making herself a seaport by exploiting a mere trickle like Buffalo Bayou. If Houstonians deride the fabulous idea of dredging the Trinity so as to bring freighters up its tortuous course to Dallas, their mirth is apt to have a hollow sound or end with a muttered comment that turning the Trinity into a seaway would be about as stimulating to Houston as opening Buffalo Bayou was to Galveston.

A matter of even more immediate concern to Texans than converting their rivers into sea lanes is the floods to which some watersheds are especially prone. Only last spring, the Trinity kept Dallas and Fort Worth residents listening eagerly for news of the water gauges. The nearby Brazos is likewise given to fits of temper in flood season, and U.S. Engineers are now engaged in building Whitney Dam across a shallow gorge cut by the stream through limestone formations. The site is 7 miles from the town of Whitney. Though the Brazos rises in New Mexico some 40 miles from the Texas boundary, the remainder of its course lies within the state. The river figured as dramatically in the history of the Lone Star Republic as San Jacinto or the Alamo, even giving its name to Brazoria, first capital of Texas. Whitney is the second dam to be constructed on the Brazos primarily to control floodwaters; Possum Kingdom Dam, near Mineral Wells, Tex., was completed in 1940.

In a commonwealth where size seems to have more than ordinary significance, Whitney Dam will set precedents in height—its 1674-foot-long concrete section will rise 167 feet above the streambed—and by creating the largest lake in the state. The latter will have a maximum capacity of 1,630,500 acre-feet, will cover an area of about 78 square miles at full level, and will be 60 miles long. Of the reservoir storage capacity, 131,000 acre-feet has been allocated to the generation of electric power, and twin 16-foot penstocks will carry the water to two Francis-type 20,700-hp. vertical-shaft turbines. An average annual power production of 85,000,000 kw-hrs. is forecast. Regulation of the river's flow will considerably benefit areas lying below the dam in other ways than flood prevention, and use may eventually be made of the impounded water for irrigation. The U. S. Corps of Engineers, which is building the structure under the supervision of its Galveston District office, expects to aid in developing the recreational potentialities of the lake.

Construction of the dam was authorized by the Seventy-seventh Congress under the flood-control acts of 1941. The

project is now estimated to cost 40 million dollars. Work on it was initiated on May 12, 1947, with the letting of a contract to the Standard Paving Company of Tulsa, Okla., for a part of the earth-fill embankment, which, with the concrete section in the riverbed, will give the dam a total length of 19,600 feet. The concrete section and portions of the earth fill will carry a 34-foot roadway that will form a link in State Route No. 22 of which 13.3 miles are being relocated to improve grade and alignment.

Some of the homesteads in the area to be inundated by the reservoir have seen Texas advance under three flags, and the impedimenta of long occupancy which must be moved elsewhere range from the contents of some 3000 graves in nineteen cemeteries and family plots to 11 miles of branch line of the Missouri-Kansas-Texas Railroad and 13 miles of main line of the Gulf, Colorado & Santa Fe.

The award made on February 9, 1948, for the construction of the concrete section of the dam and the remainder of the earth fill to L. P. Reed, Inc., of Meridian, Tex., on a bid of sixteen million dollars represents perhaps something of a departure in the letting of contracts on major Government undertakings. With headquarters in a small town near the site, this firm had never engaged in enterprises of this scope, as is evidenced by the fact that virtually all its equipment on the job is new. Reed is now at work on the contract in association with Martin & Grace, Inc., a Dallas firm.

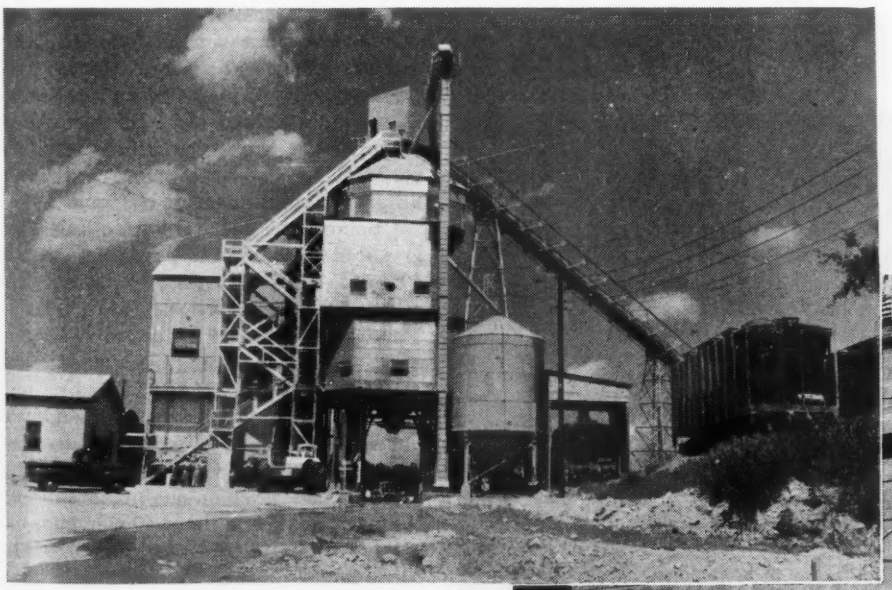
The central concrete section of the dam will be 245 feet wide at the base, and the earth fill will range up to 640 feet in width. Sixteen flood-control conduits, 5 feet wide and 9 feet high and equipped with hydraulic gates, will be built into the concrete section, together with an 824-foot spillway with seventeen 40x38-foot taintor gates. Streambed elevation at the dam is 428 feet, and the excavation for the footings is carried down to Elevation 417. Formations encountered vary from chalky limestone in keyways for abutments in the river bluffs to relatively hard limestone below river level. None of the material removed in digging the foundation for the concrete section, except some rock for riprap, is suitable for use in the earth-fill sections. These will be made up of selected materials from a borrow pit on the north bank and will be placed and compacted in the conventional manner.

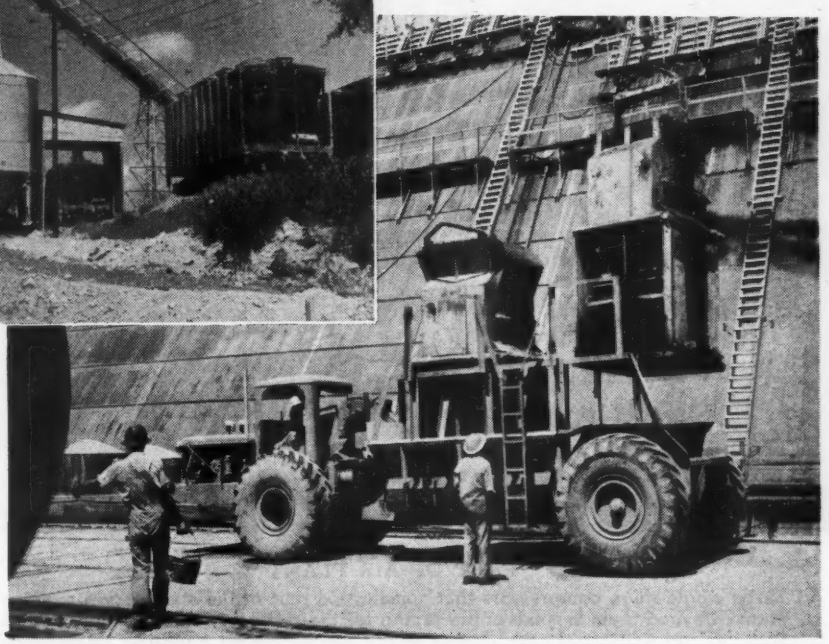
Excavation for the concrete section was begun in June, 1948. Estimated quantities to be removed, based on core-drill exploration, are 250,000 cubic yards of earth and 59,800 yards of rock. Most of the material that does not require shooting has been handled with carryalls and Super-C Tournapulls, two large tractors sometimes being hooked in tandem ahead of a Tournapull to help pick up a load of coarse material or to negotiate a heavy grade. A 3½-yard crawler-mounted diesel shovel loads rock spoil into 10-yard Tournawagons, and a considerable yardage of this material is being utilized to heighten an earth cofferdam that is now effecting first-stage diversion of the river.

Line drilling has been done with two FM-2 wagon drills mounting X-71 drifters and with two Wagonjacks having DA-30 drills. Jackbits of 2-inch size are used in putting in the 8- to 12-foot holes on 5-foot centers. Six J-50 Jackhamers and six PB-8 paving breakers are available for hand drilling and breaking. Two HK-500 portable compressors provided air for the initial excavating and are still in operation in the foundation area. A stationary compressor plant, housed in a quonset building together with ammonia compressors used in controlling the temperature of the concrete, consists of three 14x13-inch ES single-stage, V-belt-driven machines and one 2-stage Ferrabee assembly made up of two single-stage ES units—a 20x13-inch and a 12x13-inch—arranged on adjoining foundations and for dual drive from a 250-hp. motor.

Excavating was begun at the north end of the site to be occupied by the concrete section. Preparation of the footing areas and the placing of concrete are now progressing simultaneously. No grouting of foundation rock is being done in advance of pouring concrete. Instead, holes will be drilled from a grouting and drainage gallery in the completed structure through pipes embedded in the concrete for that purpose. These holes will be carried to a maximum depth of 150 feet, and steel bars of prescribed length will be anchored in their upper ends before they are filled with grout.

At a point between the north end of the concrete-section site and the normal bed of the river provision was made for diverting the stream through a sluiceway. On the bottom of the latter was





CONCRETE FACILITIES

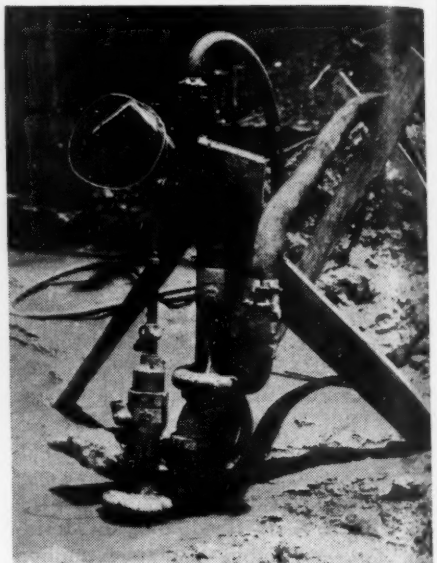
The batching and mixing plant (above) includes machinery for making tube ice with which to cool the concrete. From the plant the concrete is delivered to the placement trestle in Tournawagons that carry two 4-cubic-yard buckets. One is shown at the right as it is being lifted off by a crane to start its aerial trip into the forms.

poured a course of concrete to form a permanent footing for the dam proper, the sides being a series of concrete monoliths extending to an elevation well above the flood stage of the stream. Supplementary parts of the diversion works on the upstream side of the dam consist of a concrete wing wall carried at an angle from the face of the dam to an earth-and-rock diversion dam across the river channel. Downstream, they include an earth-filled timber-and-steel cofferdam and a concrete wall with gates to equalize the pressure in case of a flood. Closure of the gap in the dam will be the second diversion step. Then the flood-control conduits will carry the stream.

The dam will contain 522,000 cubic yards of concrete, which is being prepared in a fully automatic Johnson batching-and-mixing plant having a capacity of 200 cubic yards per hour. It is located downstream from the structure at a point that provides a short haul to sections that require the greatest yardage. Tournawagons equipped with special bodies that hold two 4-cubic-yard rectangular Blaw-Knox buckets haul the concrete to a plank-decked steel trestle paralleling the downstream face. There, two rail-mounted, steam-operated revolving cranes with 125-foot booms transfer the buckets to cantilever forms, where they are bottom-dumped by pneumatic means. All concrete is compacted in the forms with air-operated vibrators. Aggregates are brought in by rail a distance of 112 miles, and the cement is similarly transported from Fort Worth. To serve the project, the Government built an 8-mile railroad from Whitney.

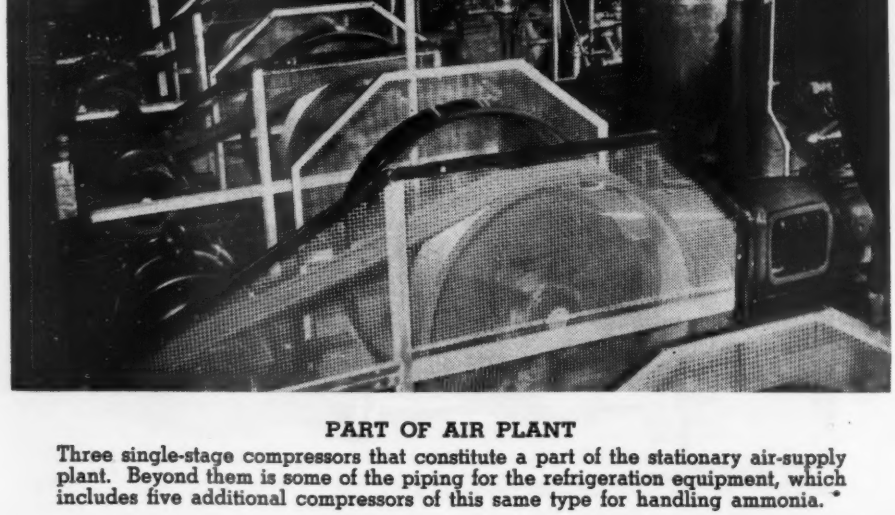
MINOR AIR USES

A chipping hammer, left, being used to smooth up concrete at a joint between two pouring lifts. An I-R sump pump is shown below removing water that had accumulated in the foundation area.



To avoid damage resulting from the rise in temperature incidental to hydration of cement after the placement of concrete, the U. S. Engineers elected to control its final temperature by starting with a cold mix. They specified a maximum of 75°F. at the mixers, and the contractors have been able to maintain levels of 68° to 69° there by the use of ice and chilled water. A Vogt ice plant, made up of two tubular freezers and equipped for the automatic control of the freezing and conveying cycles, was installed as an integral part of the batching-and-mixing plant.

The freezers operate as heat exchangers, in which water is continuously circulated through a nest of tubes surrounded by an ammonia refrigerant. As ice forms on the inner walls of the tubes, it is discharged by gravity to a set of mechanically rotated sizing blades by momentarily replacing the refrigerant with hot ammonia gas and by introducing warm water into a thawing chamber at the lower end of the tube nest. The capacity of the two units is 20 tons of ice per hour. They are served by four 10½x 13-inch, V-belt-driven ES ammonia compressors. Water for the mix is chilled to 35°F. in separate apparatus using a 9x11-inch compressor of the same type.



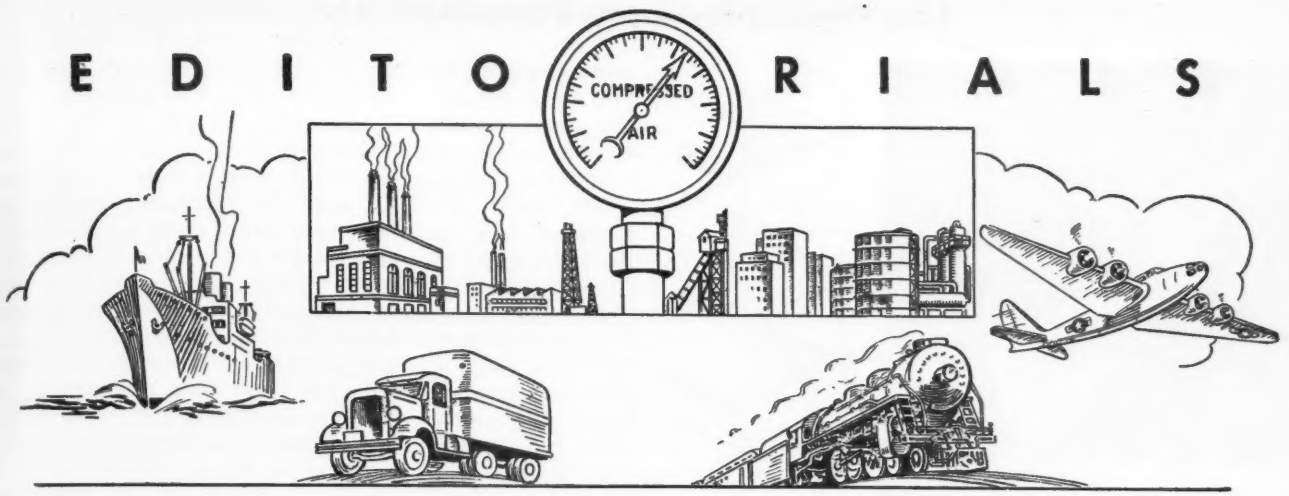
PART OF AIR PLANT

Three single-stage compressors that constitute a part of the stationary air-supply plant. Beyond them is some of the piping for the refrigeration equipment, which includes five additional compressors of this same type for handling ammonia.

Concrete in place by mid-July aggregated 90,000 cubic yards, or around 17.4 percent of the total. The contract is scheduled for completion in March, 1951. The date is more or less tentative, however, as the rate of progress is dependent upon the appropriation of funds by Congress. An average crew of 340 men, on a one-shift schedule, is employed by the contractors. The Corps of U. S. Engineers has an office on the north bank of the river and keeps about 40 men busy on inspection and engineering layout work. Most of the contractors' buildings and heavy installations are on the same side.

The project is under the direct supervision of Lieut. Col. Ellsworth Davis, District Engineer for the Corps with offices at Galveston. Mark Haima is resident engineer, and Lee R. Wilson is his assistant. The contractors are represented on the job by L. P. Reed, president; Mrs. L. P. Reed, vice-president; J. W. Grace, vice-president and general manager; and Simon Piedmont, general superintendent.

EDITORIALS



SAFETY IS BIG BUSINESS

INDUSTRIAL America is becoming increasingly safety-conscious. Later this month some 12,000 persons will meet in Chicago for five days of discussion of ways and means to reduce accidents. Executives of some of our largest concerns will drop other duties to appear on the program of the National Safety Congress and Exposition.

The scope of the safety movement is being continually expanded. Having registered encouraging progress in making jobs less hazardous, industry is now giving attention to improving the spare-time accident record of its employees. Home and travel accidents are leading causes of absenteeism and are therefore of concern to management. Fortunately, this is one line of endeavor where no discord arises with labor, and union leaders are coöperating wholeheartedly in the effort.

Further evidence of the broadening safety front is the inclusion of alcoholism as a subject of discussion in Chicago. The traditional attitude of tolerating a drinking employee just so long and then severing him from the payroll is slowly giving way. The new approach to the problem is to look upon alcoholism as a disease and to seek a cure. Concerns that have had some success with this method of procedure report that the effort has been worth-while. Their records show that a reformed drinker usually makes a dependable and desirable worker.

Steady betterment of the industrial-safety score is rewarding the campaigners against mishaps. Many companies now announce accomplishments along this line as proudly as they do a good earning statement. Constant care in avoiding risks is compiling some outstanding safety records. Take the case of the American Optical Company. One of its plants is perhaps psychologically a safe place in which to work because the firm manufactures safety equipment. In any event, its Southbridge, Mass., factory recently received the highest award of the National Safety Council for nearly three million consecutive man-hours of work without a disabling injury. The governor of the state considered the bestowal of the honor of enough importance to attend the ceremonies. Truly, the safety movement is forging ahead with big strides.

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IRON ORE FROM ABROAD

NOT a great many years ago this country felt rather secure about its supply of iron ore. The immense Lake Superior deposits that had shifted steel-making westward seemed at that time to be well-nigh inexhaustible. Two world wars and the amazing industrial growth of the nation have, however, jarred our complacency. More or less suddenly there came a realization that it would not be long until we would either have to rely in part on low-grade domestic ores or find new sources of supply outside our borders.

The steel industry moved quickly to explore both these possibilities. Research aimed at developing suitable means of concentrating the taconite that abounds on the Minnesota and Michigan ranges has been conducted quietly for a decade or more. Satisfactory progress is reported, and it appears that commercial processes will be ready for use when the need for them arises. Economic considerations will determine when that may be. The supplemental step of beneficiation will obviously increase the cost of adding material of equal ferrous content to that which we are now putting in our blast furnaces.

Meanwhile, various foreign sources of ore have been scrutinized. Lately there has been much in the news about the Labrador deposits, and their early exploitation is assured. Access to large tonnages that are so near at hand would be highly desirable in times of national emergency. From a long-range standpoint, however, still greater supplies are required to insure continued growth of our steel-making facilities.

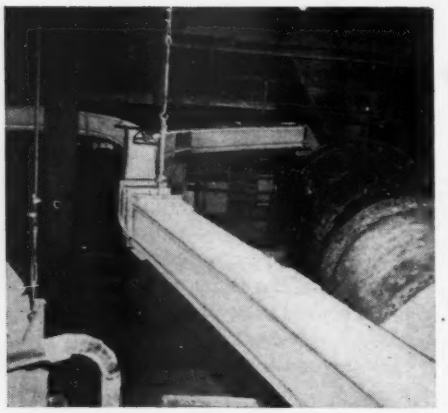
With that in mind, our steel interests have been arranging to tap the huge iron resources of South America. As a matter of fact, considerable ore has been coming from there for some years, but it is only a trickle compared with what is ahead. The first of the recently inaugurated mining ventures on the continent south of us is soon to go into operation. To bring it to the productive stage, Bethlehem Steel Corporation has expended eight years and the large sum of 50 million dollars in the Venezuelan jungle.

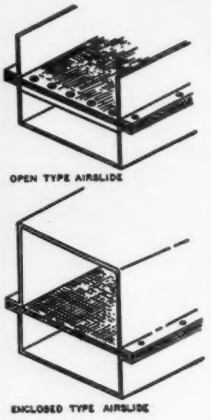
Trucks, conveyor belts, a railroad, and barges will be combined to move the ore over the mountains to the Oronoco River and thence to the port of Puerto Hierro, where facilities have been provided for stockpiling up to a million tons for transshipment to the United States. The ore occurs in a mountain peak, which will be gradually reduced, working from the top downward. It is conservatively estimated that 300 million tons of high-grade is available in the Bethlehem concession. Venezuelan officials think the total may run to several times that figure.

About 50 North Americans and 1350 Venezuelans are employed in the operations. In taming the jungle for its purposes, Bethlehem has established three settlements at interior points, each complete with dwellings, stores, schools, and churches. Under the terms of its concession it will mine 50 million tons with no obligation, after which the profits are to be divided equally with the Venezuelan government. Although ore will begin moving to the coast within two or three months, none of it is expected to reach the steel mills before the middle of next year.

Other concessions in the same general region as the Bethlehem tract are held by United States Steel, Republic Steel, and Jones & Laughlin, and these, too, are on their way towards development. Eventually, the district may rival the famed Mesabi Range that has yielded a sizable proportion of our domestic iron-ore supply for more than half a century.

Conveying by Low-Pressure Air





IN A CEMENT PLANT
This conveyor carries air-separator tailings and is split to return an accurately divided stream to two mills.

A CONVEYOR having no moving parts yet capable of rapid, efficient transport of large quantities of fine, dry materials has recently been made available by Fuller Company. The carrier, termed Airslide, consists of a porous fabric, which forms the track, and of a sheet-metal duct or air chamber underneath the track. The conveyor is erected on an incline, 4 degrees being the average for most installations made so far. Air at low pressure (about 6 inches water gauge) introduced into the duct passes slowly through the web, aerating the material on it and causing it to flow down the slope by gravity. The conveyor may be left open, or it may be provided with a sheet-metal cover, depending upon the service for which it is intended.

Advantages claimed for the Airslide include simplicity of construction, noiseless and dustless operation, high capacity with low headroom requirements, low maintenance costs, and prevention of accidents due to chain or belt drives, speed reducers, etc. It can be powered by compressed air or by small motor-driven blowers. Power consumption is said to be extremely low. At one cement mill, the work formerly done by an 800-foot screw conveyor driven by sixteen motors and as many speed reducers, representing 200 hp., is now done by an Airslide of like length and eight 2-hp. fans. The cement industry has been the principle user up to date, handling with it such raw materials as mill stream, air-separator tailings, and kiln feed, but it is also serving to transport finely ground gypsum, soda ash, barite, bentonite, lime, fly ash, and even iron ores.

Air-Operated Tool Helps Box-Spring Manufacturer

AMONG the new pneumatic tools to make its appearance is a stapler primarily designed for the manufacture of furniture and box springs but applicable for other purposes. The device has a pistol grip with a trigger mechanism to actuate it, a staple magazine extending at right angles at the lower end, and a locking nut and thumb screw at the top to adjust the driving force in accordance with the hardness of the wood. In service, it is centrally suspended above the work from a freely swinging hose reel, and a tank-type ½-hp. compressor suffices to supply the operating air. This is piped to the ceiling and fed by a flexible hose connection to an oiler on the reel and thence to the pendant hose, to which the stapler is attached by a coupling. The latter is provided with a knurled ring to detach the tool and automatically to shut off the flow of air. The unit will take staples of ¾ or ½ inch; or, by means of a separate driver-blade assembly with a squared end, it can be used to apply flat-head staples in fastening plywood to the bedding compartments of divan or sofa beds. It is claimed that one man stapling box springs with the pneumatic tool keeps eight men busy tying. It is distributed by The Kay Manufacturing Corporation under the name of Power-Line Stapler.

MAZE OF COILS
With the pneumatic stapler suspended from the ceiling, the operator can move it freely and attach the border wire to the wooden framework of a box spring without difficulty.

Comments on Two Articles

TWO articles in our June issue are the subject of a letter received from Frederic A. Snyder, a colonel in the U. S. Army Reserve Corps and an engineer residing in East Orange, N. J., because they call to mind incidents in his own life that are pertinent to the subjects discussed. Concerning *Tackle Blocks—Past and Present*. he wrote:

In 1902 my brother, the late Col. George D. Snyder, made a survey for a pipe line to convey oil to Rangoon from fields south of Mandalay. He was told that the natives in Burma had been digging wells down to the oil sands since before the time of Christ.

Instead of using a windlass, as we would do, they used a single block and a rope to raise and lower the workmen and appliances. They had a runway as long as the depth of the well. To raise an object, the workmen—or really workwomen—merely walked away from the well with the rope until the load reached the surface. To lower an object, they reversed the procedure. This is another example of the early use of blocks.

When the workmen got down near the oil sands, they used a crude diving helmet supplied with air from the surface. Otherwise, they would have been asphyxiated by the oil fumes.

The article, *Industrial Gun Has Many Uses*, elicited the following comments:

From 1939 to 1942 I was a safety engineer n the watershed department of the Board of Water Supply, City of New York. In making the various excavations for the Merriman Dam at Lackawax, N. Y., we were bothered in the wintertime with ice forming on the tops and sides of the cuts. This naturally produced a dangerous condition that was hard to deal with. I suggested to the general superintendent of B. Perini & Sons. the contractors, that he try to shoot the ice down with a shotgun. He first used a high-power rifle, but the bullets merely made holes in the ice and did no good. He then tried buck or double B shot. This gave the desired wallop. Several times a day the ice was shot down. The shots were usually placed near the lower edge of the ice, working upwards.

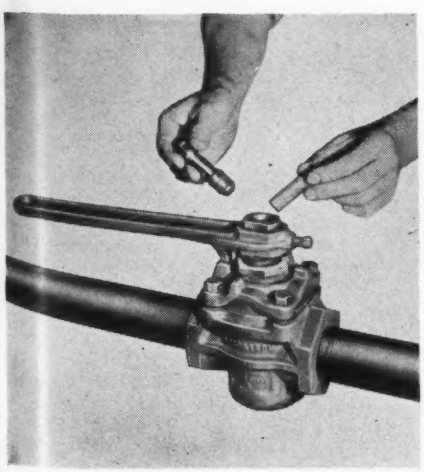
When I was a young man I was mining engineer at a bituminous coal mine in Central Pennsylvania. We had mostly English, Irish, Scotch, and Slavic miners. One foreman had been a gunner in the British Royal Artillery, serving in India. He told me that during one of the many conflicts with native tribes, they were firing at a native battery stationed on top of a cliff and near its edge. It was protected by a breastwork and was very hard to hit. The captain, a soldier of long experience, told the lieutenant in charge of the guns not to aim at the breastwork but at the cliff under it. This was done, to the amusement of the native gunners, who laughed and hooted at the dumb British. After a few shots, however, the face of the cliff crumbled and guns, natives, and all tumbled to the bottom. In shooting at ice or rock, this is a wise thing to remember.

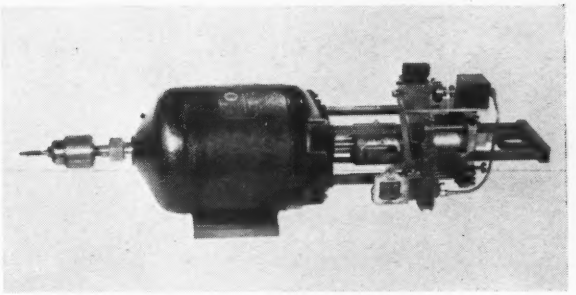
Industrial Notes

For detecting pin-point leaks in pipes, tanks, or other storage vessels, American Pipe & Steel Corporation has produced a testing device that is available in a wide range of sizes and shapes to fit inside and outside corners and circumferential and straight seams. It consists of an inspection box made of clear glass and soft rubber in which the area to be examined is encased and which is evacuated. Before this is done the seam is coated with soap suds, which indicate a leak by bubbling as soon as the air inside the pipe is drawn through the opening by the applied vacuum.

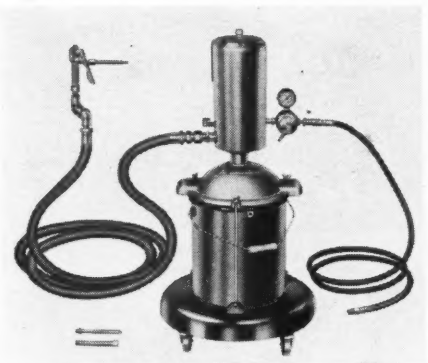
For use in connection with spray guns, Beck Equipment Company is offering a new model in its Dualheet line of electric heating equipment. It is designed to raise the temperature of the paint to 200°F. and that of the atomizing air to 250°. The unit has a rating of 3275 watts divided between two elements—a circular one at the bottom of an annular water compartment containing copper coils through which the paint flows and a central one that heats the air as it passes through a seamless brass chamber. Each is controlled by a thermostat located at the top of the housing. The electrical parts are said to be explosionproof.

What is claimed to be the first compressible lubricant ever developed for valve service has been put on the market by the Nordstrom Valve Division of Rockwell Manufacturing Company. Intended for use with pressurized plug valves of the Nordstrom type, the lubricant, which bears the trade name Hypermatic, is plasticlike in appearance and form under ordinary conditions but becomes liquid under pressure. It is said to provide automatic lubrication over a long period of valve service by virtue of the pressure put on it when first inserted in the valve—sealing seating surfaces, filling voids, and stopping leaks. The length of time the lubricant maintains its pressure depends upon the number of valve closures and the amount originally applied, but it is claimed to be considerable. When the pressure finally subsides, it may be built up again simply by adding more lubricant to the valve, as shown in the accompanying photograph, or by turning the lubricating screw. Because of its compressibility, more Hypermatic than standard lubricants can be added to a valve storage reservoir. Use of the new substance is also said to give valves longer life and to reduce the amount of servicing ordinarily required. Available in stick and bulk form.





For applying putty, calking compounds, adhesives, and other fluid and semifluid materials from original 5-pound containers, Gray Company, Inc., has in production an air-operated pump—the Powerflo Pump. A heavy-duty, double-acting unit with a pressure ratio of 4½ to 1, it is operated by a compressor



delivering 5 cfm. at a minimum pressure of 150 psi. Its special feature is a ram-type follower plate which makes use of the weight of the pump to insure positive priming at all times and to force all the material out of the reservoir. The pump and cover that supports it are bolted to the container by hold-down rods, and the entire assembly is mounted on a dolly with four removable casters. A solvent cup on the pump housing permits constant flushing of the inner material cylinder.

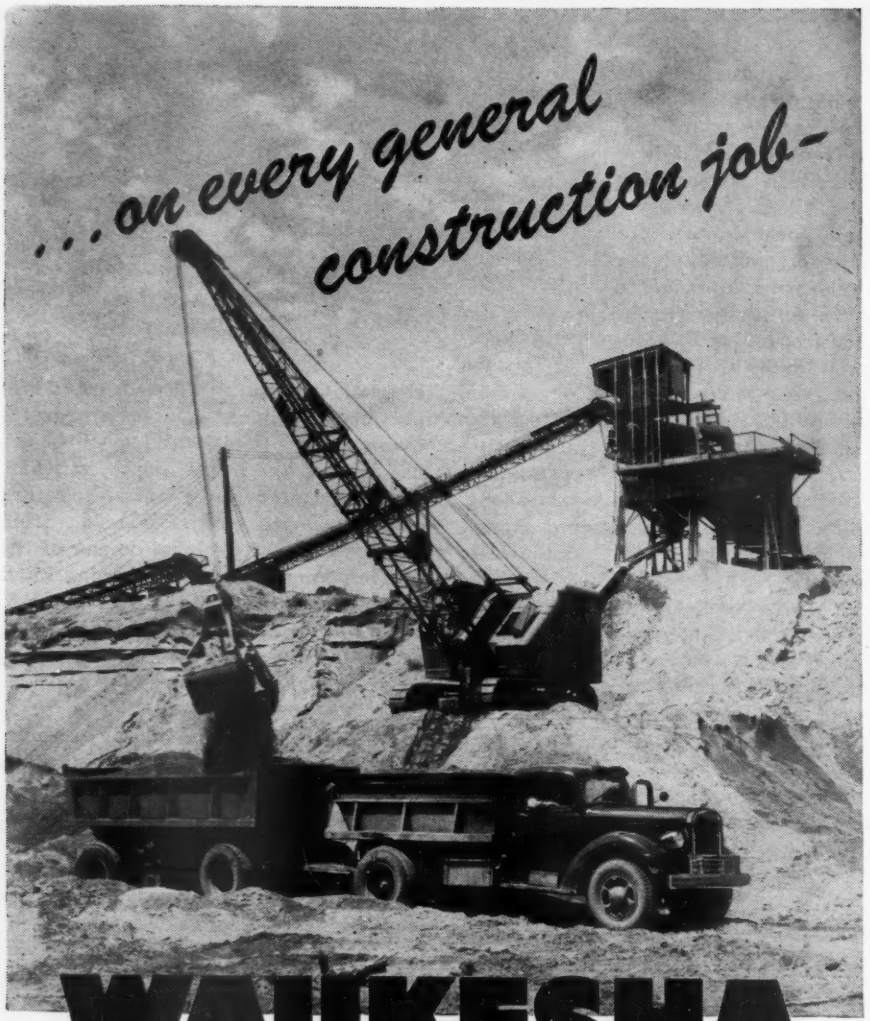
Black Industries has announced a pneumatic tapping machine which, like its drill heads, features a solid motor shaft on which the rotor shifts thoughout the full length of the stroke, a construction that is said to make for rigidity and accuracy. The unit is operated by a double-acting air cylinder actuated by a built-in 4-way valve. Adjustable needle valves control the flow of air so that the tap follows its own lead without chamfering the first threads and stripping them on the return stroke. A secondary pneumatic cylinder reverses the motor by means of a limit switch when the tap has reached the proper depth, at which time the main cylinder starts the return stroke. Depth control is held within 0.001 inch, so there is no danger of the tap breaking even when tapping blind holes. The units are designed to work in any position and at any angle and can be used either singly or in multiple on index or transfer machines.

A gigantic planer and milling machine, which can shave a sliver one-thousandth of an inch thick from a steel block the size of a railroad boxcar, has been built by the Consolidated Machine Tool Corporation and placed in operation in the Schenectady Works of the General Electric Company. The machine has a 40-foot-long table that slides through an archway 27 feet high and is set in a foundation made up of 30,000 pounds of steel and enough concrete to lay a 2½-mile sidewalk.

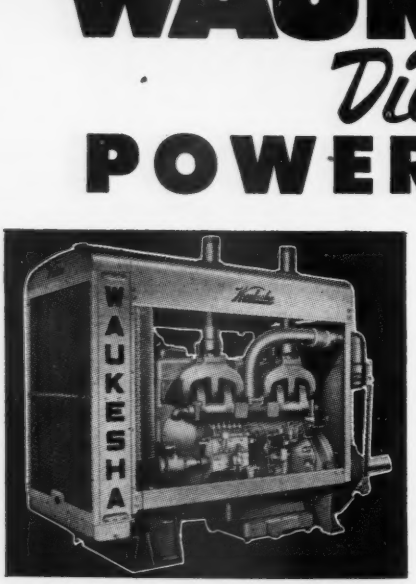
Something new in shot for peening and cleaning has been introduced by the Precision Shot Company. It is made from SAE 1065 wire for high tensile strength, hardness (46-52 Rockwell), and maximum fatigue resistance. Named Cutwire Shot, it becomes round quickly and is said to retain that shape throughout 98 percent of its service life of 1500 cycles, as compared with 2½ to 10 of conventional chilled-iron shot. Material is available in diameters of 0.014-0.072 inch.

Accidental overloading of hoists or cranes can be averted, it is claimed, by the use of a Dyna-Switch designed by W. C. Dillon & Company, Inc. The safety device slips on the hook and prevents a hoist from functioning whenever the attached weight exceeds its capacity. This is done by means of a U-shaped bar of tool steel that automatically cuts off the motor by opening the circuit, which remains open until the operator reverses the switch and removes the overload. The device can be set to function at any poundage between 500 and 10,000.

This item is just for fishermen, for it concerns a new fly box that was designed



WAUKESHA *Diesel* POWER UNITS



WAUKESHA Super-Duty DIESEL (6-WAKDU)
six cylinders, 6¼-in. x 6½ in., 1197 cu. in. displacement, 210 hp. maximum

WHY are Waukesha Diesels so specially adapted to the general contractor's needs—for powering rock crushing, gravel screening-washing machinery, conveyors, shovels, cranes, pumps, mixers, pavers, hoists, and portable compressors and generators . . .

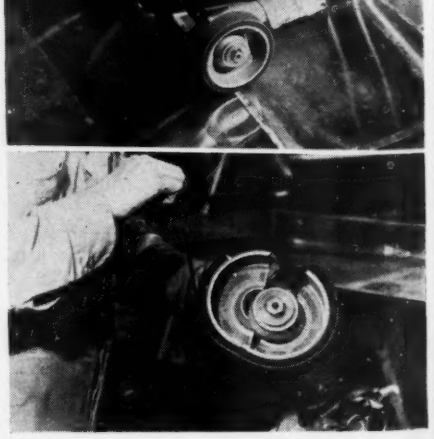
Outstandingly lively pick-up . . . quick response to power demand . . . high economy . . . ability to burn cleanly all modern "high speed Diesel fuels" of 45 cetane or above . . . starts easily . . . runs smoothly . . . maintenance is simpler and costs less . . . and Waukesha Diesels are easy to understand and operate. They range all the way from the small four-cylinder with a maximum of 29 hp., to the largest six-cylinder with its 357 hp. maximum. Bulletin 1418 tells you how Waukesha builds dependability into these Diesels—send for it.

WAUKESHA MOTOR COMPANY
WAUKESHA, WISCONSIN
NEW YORK • TULSA • LOS ANGELES

by General Electric for the Charles F. Orvis Company of Manchester, Vt. About 4 inches square, it is made of translucent polystyrene and has a snap hinge that locks it when shut or keeps the top up. The special feature, however, is an Alnico magnet that is said to hold the flies in place even in the strongest breeze and to permit their removal without damage to wings, hackles, or hooks. With room for 36 flies, the magnet can be turned in either direction for quick selection.

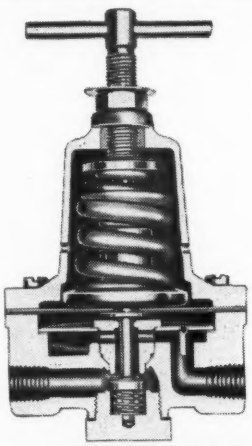
Ohio is trying out a roadbuilding technique that may prove to be well suited for secondary highways because it is low in cost and promises to provide an intermediate, rigid-type pavement of surprising strength. An improvement on soil-cement paving, a mix of cement and bank-run gravel is evenly distributed by a dump-truck spreader and rolled to a thickness of 6 inches. Next a tack coat is applied to seal in the moisture until the layer is surfaced with asphalt. The mix used is of the consistency of damp gravel and takes about half as much cement as that for a regular concrete job. The municipal airport now under construction at New Philadelphia, Ohio, is to have a 4000-foot runway of the "cement-treated-base" type.

Industrial plants using polishing and buffing abrasives may be interested in a new buffer drum that permits the use of standard-width abrasives in place of the more expensive endless-belt type. The drum is split and the halves are locked into a solid drum by a cone washer, hence the name Cone-Loc Drum Sander. The strip abrasive is wrapped around the drum and held in place by pins that recede when the washer is tightened so as to be out of the way. The tool was developed by the American Diamond Saw Company, which claims that cloth of varying grits for fine or rough work can be quickly interchanged, that the wheel does not lose diameter, does not require



dressing, and that it may be adapted for use with a flexible shaft or with a stationary arbor. The sander is made in diameters ranging from 6¼ to 12 inches in standard widths and bores in rubber-cushioned form. A 6¼-inch felt-cushioned type is also available.

Positive protection against "creep" is one of the features claimed for the new Norgren relieving-type pressure regulator designed for line and working pressures up to 400 and 250 psi., respectively, and for lines carrying air or noncorrosive



gases, as well as fluids such as oil and cold water. According to C. A. Norgren Company, the action of the valve is simple and positive. The valve opening is in the lower-spring rest which pivots on a ball-end pin and automatically adjusts itself to any eccentricity. Construction permits downward adjustment of pressure without bleeding the line, an added safeguard against damage to parts incident to pressure surges. Baffle plate with siphon tube insures greater air flow with less pressure drop than conventional regulators having diaphragms, valve ports, and regulating springs of the same proportions. Valve is easy to install and to maintain and can be disassembled with a crescent wrench and screwdriver without removing it from the line. Made for pipe sizes from ¼ to 1 inch.

With Russia our principal source of manganese, which is used extensively in the hardening of steel, a statement made by Richard D. Hoak, senior fellow of the Mellon Institute, Pittsburgh, Pa., is of great significance. Speaking at a regional conference of the American Institute of Chemical Engineers held recently in Montreal, Que., he said that manganese can be recovered economically from low-grade ores by a new process which involves treating them with acids, selective removal of impurities, and isolation of the manganese in the oxide form. Application of the process may have an important effect on reducing this continent's dependence on Europe for this essential element. There are extensive reserves of low-grade in the States.

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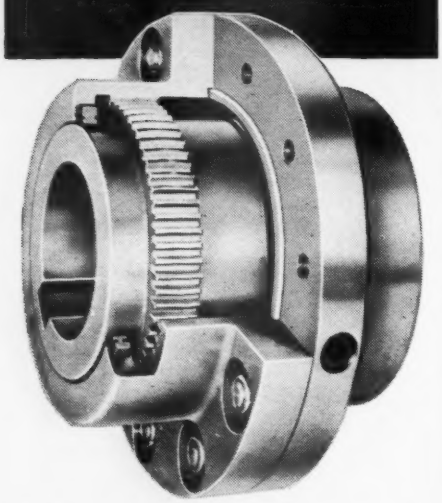

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Industrial Literature

United States Rubber Company, Rockefeller Center, New York 20, N. Y., will send upon request a new 28-page catalogue giving details of construction and design, engineering, and performance data on its line of transmission belting. Also included are tables on belt speeds, arc of contact, friction, horsepower correction, and service factors, as well as information on the analyzing of belt drives and on the selection of the proper belt for a particular application.

Liquid-level controllers, both direct-connected and air-actuated, are described in a free 32-page bulletin, No. 48-1, issued by Minneapolis-Honeywell Regulator Company, Wayne & Roberts Avenues, Philadelphia 44, Pa. Construction features and typical applications of the controllers are described and illustrated with schematic drawings, sketches, and photographs. Diagrams, capacity charts, flow characteristics, pressure-temperature rating charts, and dimensions are some of the engineering data included.

Rubber and asbestos products for the petroleum industry are treated in a 16-page booklet put out by Raybestos-Manhattan, Inc. Covering products used in the production, refining, transporting, and maintenance phases of the industry, it describes new products and gives information on rotary and other types of hose used on drilling rigs; oil-loading hose for ship and tank cars; butane and airplane fueling hose; refinery, fire, and still-cleaning hose; belts for drilling and pumping; brake blocks for oil-well drawworks; and packings and gaskets. Copies may be secured by requesting Booklet No. 6903 from the Manhattan Rubber Division of the company at Passaic, N. J.

Products for the Stone Industry is the title of a 64-page booklet published by Norton Company and dealing with abrasives made by it for industrial application, including the fabrication of granite, marble, limestone, sandstone, soapstone, slate, etc., for building, monumental, and other purposes. Methods by which each abrasive is manufactured are described, and recommendations are made as to the kind and size that should be used for each of the many operations involved. Some of the services covered are: contour grinding, coping, molding, gritting and honing, polishing, surfacing with portable grinders, pressure blasting, and tool sharpening. A glossary of terms used in the stone industry is included in the booklet, a copy of which may be secured by writing to the company at Worcester, Mass.

A leaflet stressing the importance of being fully informed about turbo-blowers before making a selection is obtainable from Ingersoll-Rand Company, 11 Broadway, New York 4, N. Y. Because of the need of a better understanding of blower operating characteristics among users, the leaflet describes briefly and graphically the capabilities and limitations of a centrifugal blower. Examples are given to show how large discrepancies in the performance of a blower result from intake and gas conditions that differ from those for which the unit was built. Because the designer cannot guess the nature of the gas nor the conditions under which it comes to the blower, the operating conditions surrounding a planned installation must be given careful consideration to establish the correct value and range of all variables. A sample inquiry data sheet has been incorporated in the form so that persons charged with the selection of a blower for a particular application will know what information the manufacturer has to have to provide a machine that will satisfactorily meet requirements. Requests should be made for Form 8257.

Power feeds for machine tools are the subject of a bulletin recently issued by The Bellows Company, Akron, Ohio. Designed primarily for use on small drilling machines, the air-actuated devices are also suitable for feeding a wide range of other machine tools designed for tapping, reaming, threading, counterboring, milling, grinding, etc. Electric controls on the power feeds enable the machines to which they are fitted to operate continuously with practically no attention so long as they are supplied with work. The company also makes a heavy-duty unit that replaces manual feeding in heavy-duty drilling, milling, and grinding operations. Copies of Bulletin No. DF-105R will be sent upon request.

Copies of a 16-page catalogue containing descriptions, specifications, illustrations, and features of the complete line of Hanna valves can be obtained from Hanna Engineering Works, 1765 Elston Avenue, Chicago 22, Ill. The valves are used for the control and operation of both single- and double-acting air and hydraulic cylinders over a wide range of operating pressures. Types discussed include foot- and hand-operated control valves, adjustable and hand-operated speed-control valves, solenoid- and air-operated control valves, and cam-, lever-, and foot-operated pilot valves. Also included in the booklet are a number of complete circuits showing the arrangement necessary to achieve the desired end.

A new and improved universal pneumatic die cushion for use on punch presses is the subject of a folder obtainable from Dayton Rogers Manufacturing Company, Minneapolis 7, Minn. Designed for use with deep-drawing operations, for pressure-pad control on form dies, for stripping blanks and ejecting slugs, and for all cushion applications, the device is available in four standard sizes ranging in capacity from 25 to 170 tons and in special sizes for larger capacities. A built-in hydraulic relief valve protects the punch press against overloading and can be adjusted for maximum press capacity and sealed, or set for any lesser tonnage desirable in order to prevent damage to any tooling or special die setup being used. The folder and an engineering catalogue may be obtained from the company.

Denver Equipment Company has prepared a bulletin telling the story of froth flotation—its discovery, theory, and application, and the steps involved in recovering substances. The different types of machines are described and their operation discussed. Originally developed for recovering mineral values from complex ores and now used extensively for that purpose, the flotation process also serves many other industries. Included among the latter applications are the de-inking of paper pulp; the recovery of oils, greases, and metal filings from manufacturing wastes; the processing of refuse from canneries, meat-packing plants, distilleries, and textile mills; the extraction of rubber resins from vegetation; the peeling of coarse hulls from wheat grains; the recovery of fungus growths for use in medicines; the removal of copper from gasoline; and the recovery of napthalene from coke wash water. Interested persons may obtain copies free of charge by writing to the company at 1400 Seventeenth Street, Denver 17, Colo.